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TABLE OF CONTENTS

	Page
LEADING ARTICLES:	
Erecting Bridge Spans by Sliding them Forward from the Shore (illustrated)	369
Experience with Skylight Construction for Railway Train Sheds	370
The Design of Concrete-Steel Arches (illustrated). E. J. McCaustland	373
A Kerosene Hoisting Engine	375
Method of Computing Daily and Monthly Discharge of Streams with Sandy, Changeable Bed (illustrated). E. C. Murphy, Assoc. M. Am. Soc. C. E.	380
A Conduit Electric Railway in London, England (illustrated)	381
The Control of Humidity by Means of the Humidostat (illustrated). W. S. Johnson, M. Am. Soc. M. E.	383
Concrete-Steel Tanks for Acid Liquor Under Pressure (illustrated). A. C. Arend	384
Some Observations of Sewage Farming in England (Editorial Correspondence)	384
The Railway and Transportation Situation in Madagascar (illustrated)	387
Tests of Sand-Lime and Sand-Cement Brick and Concrete Building Blocks. A Marston	387
Combination Hydraulic and Dipper Dredge for the Mexican Government (illustrated)	388
The Fallacy of the Tests Ordinarily Applied to Portland Cement. Richard K. Meade	390
ENGINEERING NEWS OF THE WEEK	375
EDITORIAL COMMENT.—The Rapid Deterioration of Trainshed Roofs——Humidity in Artificially Heated Buildings——Needed Precautions in the Design of a Pipe Gallery System——Underground Chambers at Street Intersections——The New Competitors of the Steam Engine	376
EDITORIAL.—A Schedule of General Clauses to be Used as a Guide in Drawing Specifications	377
LETTERS TO THE EDITOR.—Durability of Iron Imbedded in Concrete: Ernest L. Ransome——Publishing Details of Engineering Construction: E. Kilburn Scott——Specifications for Clearing Right of Way: E. G. Haines, Assoc. M. Am. Soc. C. E.——The Cost of Concrete Blocks for Manholes: W. G. Federlein——Sand Drifts on a Southern Texas Railway: Samuel Young——The Corps of Engineers of the U. S. Army, and River and Harbor Works: Francis R. Weller, C. E.——Some Former Experiences with Lighthouse Construction on Diamond Shoals: "The Captain"——Methods of Overhaul Computation Compared (illustrated): H. H. Wadsworth, M. Am. Soc. C. E.——Notes and Queries	378-379

ERECTING BRIDGE SPANS BY SLIDING THEM FORWARD FROM THE SHORE.

In our issue of Oct. 22 last (p. 375) we illustrated a novel method of erecting a bridge over the River Saone in France, in which the shore spans, each of about 150 ft. length, were erected on shore and shoved forward over the stream.

We are now informed by Mr. Wm. Pagan, Chief Engineer of the Queensland Railways, that a similar method was adopted in Queensland in 1895 for a much larger structure. Mr. Pagan writes as follows:

Sir: I was much interested in the description and sketches of "a novel method of erection" adopted for a bridge over the River Saone in France, in your issue of Oct. 22. I venture, however, to say that the method was adopted in this State in the year 1895, when the contractors, Messrs. John McCormick & Son, launched a 340-ft. complete double-track railway bridge span weighing 600 tons in a similar manner.

I enclose four photographs showing: Fig. 1 the shore end of the span and supporting trollies; Fig. 2, the river end before the weight was taken by the vessel; Fig. 3, the vessel in position with the weight on, the outer pile pier being removed; and Fig. 4, the launch.

The bridge was designed and built by the late Chief Engineer for Railways, Mr. H. C. Stanley, M. Inst. C. E., who had as Assistant Engineer for both indoor and outdoor work, Mr. F. L. Kier. I am, sir,

Yours truly, William Pagan,
Chief Engineer, Queensland Railways.

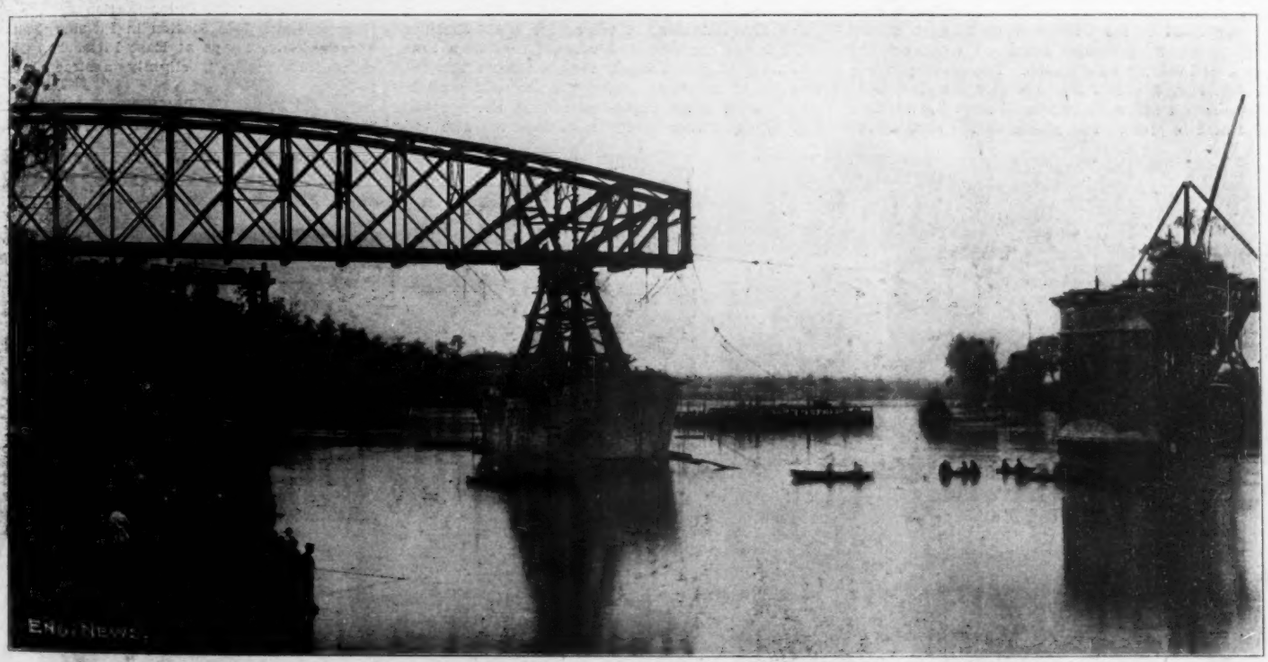
Brisbane, Queensland, Australia, Dec. 7, 1903.

We may add to the above a parallel case from Finland, in northwestern Russia, where a railway bridge of 410-ft. span was erected by this method during the years 1902 and 1903.

The railway system of Finland has in the past two years been extended northward by a line from Uleaborg to Tornea, both cities on the Gulf of Bothnia. Tornea is on the boundary between Finland and Sweden. The railway parallels the shore, a little over a mile inland, and therefore makes a number of important river crossings. The largest stream in that region, the Kemi, is crossed at the location of an island, which forms a deep channel on one side and a shallow but wider branch on the other. The latter is crossed by a series of through-truss spans, 148 and 197 ft. long c. to c. The deeper branch, the Isohaara, has rock bottom and a strong current; it is used for logging in the short summer, while in early winter and in spring great ice-masses move downstream. Channel piers seemed out of the question, and a single-span crossing was adopted, with a span of 410 ft. between rocker-pins.

The time available for erection was only about three months, the spring highwater ending in July, while the autumn ice-jam may begin before the close of October. It seemed impossible to build falseworks, erect the 410-ft. span and remove falseworks, in this short time. On this account the plan of building the bridge on shore, in axial line with its final position, and launching it forward into place by the use of a float under the outshore end, was decided upon.

The work was carried out very successfully, although delays in the arrival of material did not allow of finishing the entire work on the bridge in one season. The bridge was erected on the finished railway embankment on shore, with a length equal to four main panels (at 34 ft. each) projecting out over the river and resting on falsework built in the river. A deposit of sand on the bottom along this shore made it possible to drive piles for the falsework. The embankment was paved with transverse timbers along the line of the lower chords of the bridge, and the struc-



ERECTION OF A 340-FT. DOUBLE TRACK RAILWAY BRIDGE SPAN IN QUEENSLAND. (FIG. 4.)

ture was erected on blocking over these ties. When it was ready for launching, a slide-way of four longitudinal 22-in. I-beams was placed under the inshore end, and the roller-end shoes placed in position to slide on the track formed by these I-beams. The rollers and sole-plate were omitted from the shoes; the bottom of either shoe was provided with an iron plate projecting out at the rear end to carry the hydraulic presses,

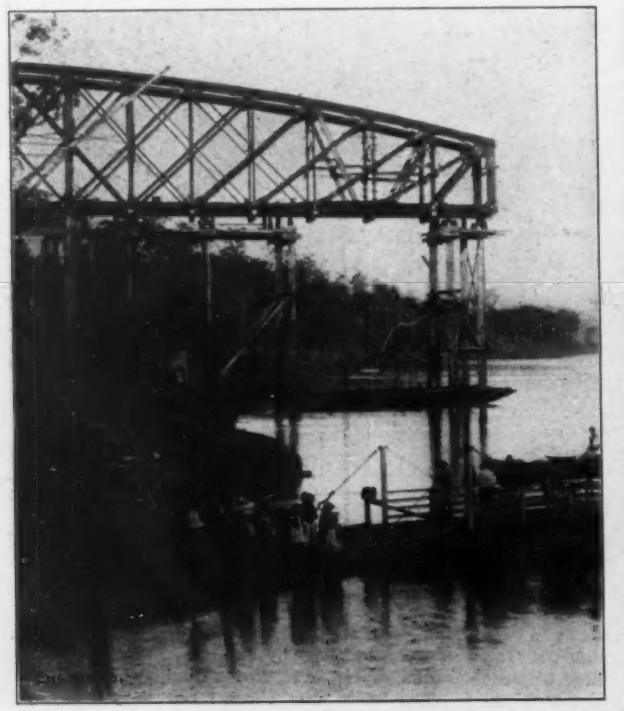
FIG. 1. SHORE END OF QUEENSLAND BRIDGE, ON TRUCKS FOR SLIDING FORWARD.

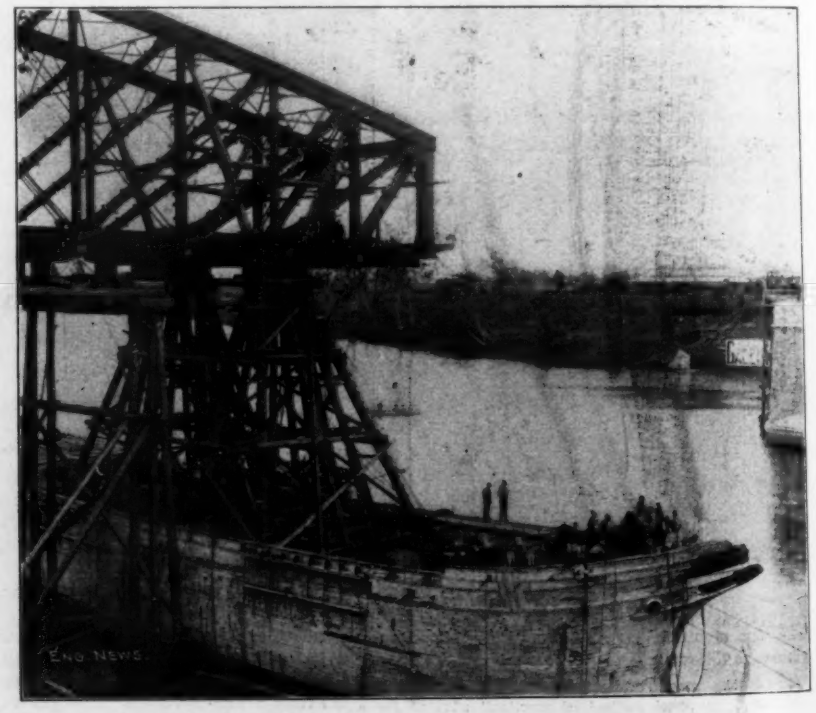
and under this plate a wooden strip faced on the bottom with brass. The brass formed the actual sliding face moving over the I-beams. It was lubricated with oil pumped through holes in the plate. The presses were actuated by hand-pumps (using glycerine) mounted on the bridge itself. The plungers of the presses butted against a shoe or dog fixed to the I-beam track in such a way that it could be readily advanced whenever the press had completed a stroke. The accompanying sketch, Fig. 6, shows this dog and the pins passing through the webs of the I-beams by which it was held in place. The pinion on the ends of the pins, meshing with the rack on the dog, served to advance the latter and thereby return the press-plungers, the pin moving in a long slot cut in the plate B of the dog.

The river end of the bridge was supported for the launching by a framework resting on two specially-built pontoons, each 98 × 19 ft. in ground-plan. This pontoon support was placed under the first and second main panel points from the end, part of the pile falsework being removed to admit it. The outshore end was held and guided by steel cables anchored on shore, as can be seen in Fig. 8.

When the bridge was ready for launching the temperature fell rapidly. There was only time to secure the bridge in position for winter before ice began to come downstream in large masses. Two days more would have seen the bridge in final position. To secure the bridge for the winter it was launched forward half a panel-length so as to bring the fourth main panel-point from the river end over the abutment; the inshore support was placed at the third panel-point from the inshore end. All falsework and blocking were removed, leaving the bridge resting on two pairs of supports.

The final launching of the bridge in the summer of 1903 was accomplished without trouble, a time of about 36 hours being required from the beginning of moving. After the far end was in place on its shoes (fixed-end shoes), the pontoon was brought over to the near side to raise the end in order that the slide-ways might be removed, and the bridge was then lowered down to bearing upon the rollers. According to a recent article in the "Zeitschrift des Vereins Deutscher Ingenieure," from which the preceding is taken, the bridge weighed about 800 tons. The friction on the slide-ways amounted to about 50 tons. The bridge was built and erected by the Harkort Company, of Duisburg, Germany; Mr. C. Hahn was in charge of the erection of this and several other bridges on the Torne[a] Railway for the Harkort Co. The work was [done] under the supervision of the chief engineer [of] the Tornea Railway, Mr. K. Snellman. [It] may be noted that the location of this bridge [is] lat. 65° 47', less than 100 miles south of the Arc[tic] Circle.





FIGS. 2 AND 3. RIVER END OF QUEENSLAND BRIDGE.

EXPERIENCE WITH SKYLIGHT CONSTRUCTION FOR RAILWAY TRAIN SHEDS.

The problem of skylight construction for train shed roofs has long defied satisfactory solution by railway managers. Despite the purchase of the most expensive glass and the adoption of the most advanced methods of installation, the breakage and destruction of train shed skylights has entailed a large expense for maintenance and has caused no little worry for the safety of passengers and others using railway stations. While these broad facts are familiar to railway engineers, there is little known in detail about the character and extent of skylight failures, and particularly about the causes which are responsible for the trouble. With the view of getting definitely at some of these details, one of the leading eastern trunk line railways recently appointed a committee of practical maintenance of way officials to investigate and report on train shed skylight failures and their remedy. This committee examined the Broad Street Station train shed, Camden and Reading Terminal train sheds, and other structures in Philadelphia containing wire, rough and ribbed glass; it also examined the train shed at Jersey City, the North German Lloyd Steamship Piers at Hoboken, the train shed of the N. Y. C. & H. R. R. R. Co., the Macy Building, and other structures in New York; the South Union, North Union, and Back Bay Stations and the Charlestown Navy Yard, in Boston; the Union Station and the Pittsburg & Lake Erie Station in Pittsburg, and the Westinghouse Shops at East Pittsburg. The report of its findings, slightly abstracted, is as follows:

BROAD STREET STATION, PHILADELPHIA, PA.—Mr. M. H. Barton informed your committee that as the train shed has only recently been assigned to the department with which he is connected, he is unable to give data as to the percentage of glass broken within a given time. This train shed was erected about ten years ago. When he took charge there were numerous complaints because of the leakage, etc., in skylights. On examining the shed it was found that the metallic supports of the glass in the skylights were badly corroded and in several instances entirely de-

FIG. 5. BRIDGE OVER KEMI RIVER, FINLAND, AFTER LAUNCH.

stroyed by corrosion. There was also a great percentage of broken glass, which he concluded was due to the bad condition of the metal superstructure, caused by the action of the sulphurous gases, and the expansion and contraction of the train shed roof. He therefore concluded that some radical changes should be made in the system of the skylights and ventilation of the train shed. He immediately began making repairs to skylights by substituting wooden supports for the glass. Within the past six months, July 1 to Dec. 31, 1903, he has expended on repairs to the skylights $2,430 (about 85% of this was for labor). The glass for these repairs, and a portion of the labor was furnished by the Chief Engineer Maintenance of Way, of the cost of which he has no record.

Your committee in making a careful examination of the skylights, especially in the top range, noticed that the glass was considerably cracked, resulting in leakage. This breakage is due to various causes; some to snow slides and wind storms (one of which tore off some of the copper from the roof), and some to the contraction and expansion of the metal forms by which the glass is carried. We have discovered that the corrosion suffered by the metal frames, has materially affected the bearing surface, making it very irregular and incapable of properly sustaining the glass. We think from our observation that this corrosion results in the seepage of moisture, which reaches cracks in the wire glass and probably accounts for its separation.

We believe that the introduction of wooden bars, such as are now being placed in this train shed, in making repairs to skylights, where the metal supports have been entirely destroyed by sulphurous gases, will prolong the life of both frame and glass. The new wire glass recently placed in this train shed and supported by wooden bars, is of too recent construction to warrant an expression of opinion at this time. We believe, however, that a careful scrutiny of this recent installation will recommend this system of sustaining glass. We are led to believe that, from the best information obtainable, the glass above referred to as being broken in the top ranges, is the first wire glass purchased for this station about 1893. The sizes of the wire glass in this station range from 18 ins. to 23½ ins. in width, and from 68 ins. to 72 ins. in length. The glass vertically set in the gable end of this train shed is found in good condition.

READING TERMINAL TRAIN SHED, PHILADELPHIA, PA.—Mr. H. G. Carnes, Station Master, in accompanying your committee, stated that this station was built twelve years ago. The glass installed in the skylights was ⅜-in. ribbed glass,

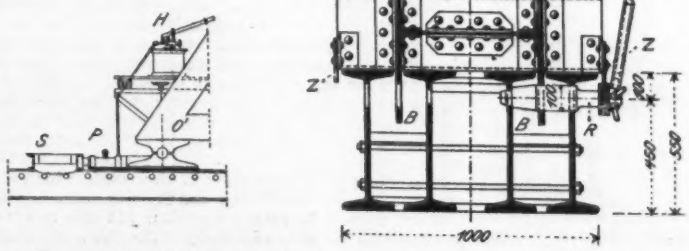


FIG. 6. ARRANGEMENT OF HYDRAULIC PRESSES AND DOGS FOR LAUNCHING BRIDGE.

with No. 15 copper wire, 2-in. mesh, hung beneath to catch particles resulting from breakage. A number of breakages resulting in falling glass have occurred; the most serious that was recalled at the time, was due to breakage which resulted in the fall of one piece of glass weighing about 4 lbs., which passed through the copper netting, and struck the top of a passenger car, embedding itself in the roof thereof. They have replaced the wire netting twice since first construction, and are now engaged in renewing the netting for the third time. The wire which was taken down was found pretty well eaten up by the gases; although the locomotives entering this shed burn anthracite coal, and there seems to be comparatively little smoke, but considerable gas with which to contend. The amount of gas, however, emitted by the locomotives while in the shed has been such as to necessitate making louvre openings in the crown of the roof, and some openings in the ends and upon the sides, to create circulation sufficient to work out some of the gases, and they expect less trouble hereafter. In the skylights they have used wire glass here and there, but do not recall any breakage, because of there being comparatively little of it, and the breakage, if any, amounted to so very little as scarcely to warrant serious attention. On examination we found a large amount of broken glass, and the wire netting which had been taken down completely eaten up.

PENNSYLVANIA R. R. TRAIN SHED, CAMDEN, N. J.—In company with Mr. Bodine, Station Master, we examined the train shed roofs at Camden, and found the construction there altogether different from that of the Broad St. Station train shed, and the Reading Terminal train shed. This train shed is lighted by a monitor form of skylight, in which the glass is vertically set and is of ⅜-in. hammered glass, a very small percentage of which we found broken. The sizes of the glass are considerably smaller than in the train sheds above referred to. Over the lobby are a number of Hayes' skylights, in which are installed ⅜-in. hammered glass with copper wire protection beneath. Mr. Bodine stated that a great wind storm which occurred some months ago resulted in blowing out a section of the glass in the west end of this train shed. This glass fell upon the skylights over the lobby, and crushed through, carrying the glass and wire netting to the floor beneath, and involved considerable expense for repairs. Referring again to the skylights with vertical sections of glass, Mr. Bodine stated that several falls of glass from the monitor settings have occurred.

JERSEY CITY TRAIN SHED.—Mr. F. S. Reynolds, representing the above station, states that the train shed at Jersey City was completed in 1891. The skylights installed, were what is known as the "Helliwell" system, using imported steel bars and American ribbed glass ¼-in. thick, zinc caps and brass bolts, and the whole guaranteed for one year. The work was of such an unsatisfactory nature, as to warrant refusal of final payment. This train shed roof was especially designed to render it waterproof, but its failure in this respect necessitated the entering into a contract with another contractor, in 1894, for the sum of $12,000, by which he agreed to make the skylights water-tight. In so doing he used an elastic cement, the glass being ribbed, with no protection underneath to prevent the fall of broken glass to the platform. The same contractor was awarded an additional contract of $4,000 for installing copper wire netting beneath for protection from falling glass.

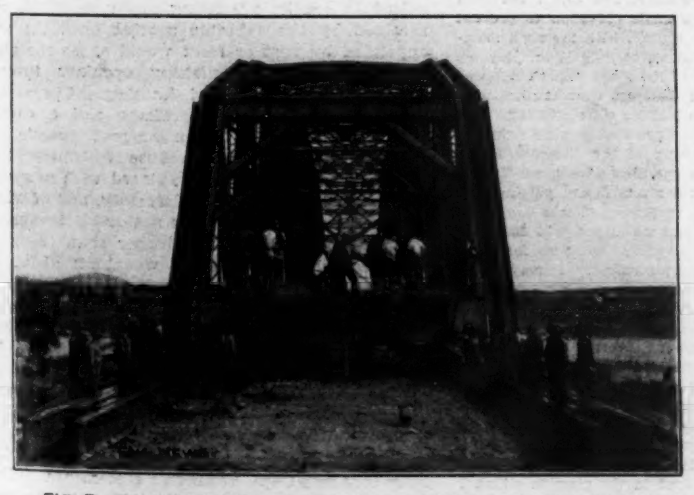


FIG. 7. INSHORE END OF KEMI RIVER BRIDGE DURING LAUNCH.

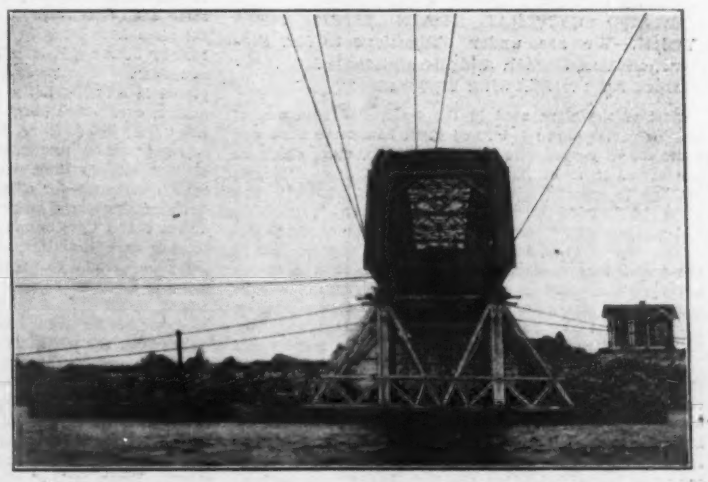


FIG. 8. RIVER END OF KEMI RIVER BRIDGE DURING LAUNCH.

Up to 1898 all the glass in skylights was ribbed. From April 25, 1898, to March 30, 1900, there were purchased 1,740 lights of rough wire glass of various sizes ranging from 17 x 51 ins. to 22 x 52 ins., and from ¼-in. to ⅜-in. thick; these were purchased for repairs. A three months' test was made of the glass in the train shed roof to find the percentage of breakage of wire and ribbed glass. A count was made on August 8, 1900, to find the amount of broken glass in the train shed. Out of 9,548 lights in the skylights, which constitutes 93% of the whole, there was found 2% broken, while of the wire glass, 746 in number, constituting 7% of the whole, there was 13% broken. On Oct. 1 the count showed 2 3-10% of plain glass broken, and 14 3-10% of wire glass, an increase of 3-10% for plain and 1 3-10% for wire, there being the same percentages of plain and wire glass as previously stated. On Dec. 12 the count showed 2% of plain glass broken and 14 3-10% of wire glass, there being no increase owing to the fact that 45 plain lights and 11 wire lights previously broken were replaced with wire glass. The bars in the train shed of the "Helliwell" system had become loose from the fact that the gases had eaten the hook bolts off that held them in place. In the Spring of 1900 a wind storm struck the northwest end of the shed, blowing out a section of the upper skylight. As the bars that had been adopted from past experience, had been so unsatisfactory, it was decided to substitute a wooden bar, which to all appearances is very satisfactory. In this section wire glass was installed. In the Spring of 1902 a section on the southwest corner was blown out in the same manner. In renewing this section, wooden bars and hammered glass ⅜-in. thick were used with copper wire netting 2-in. hexagon mesh No. 15 gage beneath.

At the present time there are in skylights 8,027 ribbed glass, 1,538 hammered glass, and 605 wire glass; the total being 10,170 lights. There are 413 broken. The percentages of the several kinds of glass broken are about equal.

On examining the train shed we found a section in the upper skylight west end 27 ft. 6 ins. × 156 ft. being removed on account of the dangerous condition of the bars. The glass removed is held in cases ready for replacement. We not only find the bars which were taken out of this portion of the skylights badly corroded and eaten away, but also the remainder of the steel bars in skylights are in a similar condition. Here we found a copper clip had been designed and installed to clamp the "Helliwell" bar down to the Z-bar to prevent the wind pressure from blowing out the skylights. Wherever this clip came in contact with the bar, the sulphurous gases have destroyed the bar at the point of contact, allowing the clip to fall to the platform. These clips we find were of an expensive nature, and proved unsatisfactory. We found that wherever they are taking out steel bars, they are substituting wooden bars with wooden caps, which we think should be of zinc. We found also that there is insufficient ventilation in this train shed to relieve it of smoke and gases. The conditions represented in F. S. Reynold's report with reference to broken glass are fully borne out by our observations.

GRAND CENTRAL TRAIN SHED, NEW YORK.—We are under obligations to Mr. Stevens, Station Master, and his assistant, Mr. Henderson, for the following statements:

Most of the glass used in the train shed skylights of this station is ⅛-in., ¾-in. and ½-in. hammered glass and protected by copper wire nettings beneath, upon which we are called to make repairs daily and have considerable leakage to contend with resulting in wet platforms and some snow during the winter months. We employ painters and glaziers almost constantly, but in spite of our painstaking care, a great deal of corrosion and waste occurs in the metal construction, and as you will observe to-day much of the metal is pretty well eaten up. We have considerable wire glass in use, but it is scattered and we have not kept any particular account of breakage. We do not think that it amounts to much. The annex train shed, which is of much less height than the train shed proper, has been reglazed within the past 14 months with hammered glass. Broken glass is prevented from falling on persons using the platforms by copper wire netting hung about 6 ins. below the glass, and with this we have considerable trouble. In this shed, the gases from the locomotives, notwithstanding the fact that we use anthracite coal almost exclusively, has resulted in turning the copper wire netting to green powder, which falls upon cars and platforms and the waste is such that we are constantly engaged in renewing the wire netting. We use No. 15 wire with ¼-in. mesh and we have found that glass when broken frequently passes through it, the copper wire netting having been eaten out by the gases. In the annex shed we have been obliged to hang at a distance of a few feet above the car roofs supplementary wire netting to catch the glass that may pass through the netting hung immediately beneath the glass, and we find it necessary to watch this very closely. We scarcely complete hanging this netting before it is necessary to begin all over again. We think this is due to the fact that the netting is but a few feet above the stacks of the locomotives and the action of the gasses upon it is more direct.

We find upon observation that the construction of this train shed is similar to that of the Reading Terminal at Philadelphia, and that about 65% of the glass in the skylights is broken, and that the metal portion of the roof other than that covered by skylights, is covered with galvanized corrugated iron in which there are numerous holes and the entire metal construction is badly affected by the gases. It was noticed that the glass set in the ends of the train shed shows a comparatively small per cent. of breakage.

NORTH GERMAN LLOYD STEAMSHIP PIERS, HOBOKEN, N. J.—Capt. Walter H. Whittemore, Engineer, stated that in his original plans for the installation of glass in the Hamburg and North German Lloyd Piers, aggregating about 240,000 sq. ft., he provided for ¼-in. wire glass in sizes averaging about 20 ins. × 72 ins., and based his calculations upon the observations he had made of other similar installations. He said:

I have some very fixed beliefs, one of which is that flat skylight installations are rarely satisfactory because of the atmospheric and climatic conditions with which we have to contend. Another is that cracking in wire glass is what might be expected in any glass, and it is not due to the contraction of the wire within the glass. I have had, within sight of my desk constantly for over two years two sheets of wire glass exposed to the intense rays of the sun, and degrees of heat inside up to 76° F., and I have had the sashes opened and closed in all imaginable conditions of weather, with the object of discovering if contraction or expansion would result, and you will notice to-day that the glass is in perfect condition, and this in conjunction with my observations upon the piers, convinced me that cracking in glass is not due to the contraction of the wire mesh which is incorporated in glass of this description. In consequence of the climatic changes as above mentioned, I provided for monitor skylights. These piers are 900 ft. long, and connect with a terminal building about 850 ft. long on the land end; the construction above low water mark is of heavy steel and thoroughly braced and tied together, making as rigid a structure as it is possible to provide.

I recall that, about the time the contracts for glazing were let, I was taken ill with typhoid fever, and some changes that I had contemplated were not provided for. The changes which I contemplated were reductions in the sizes of glass originally specified. Upon my recovery and return to work, I had occasion to observe the glass installed and my examination convinced me that the hazard of breakage was materially increased by reason of the glass being laid against rigid angle bars, and bolted and clamped down as tight as it could be in order to meet the driving storms to which the piers are subjected. In consequence, I concluded it of importance to change the sizes in the work remaining to be done, and this I did with some additional cost. I also made provision to prevent the glass from being in close contact with the rigid members by allowing ⅛-in. all around, making ¼-in. play top and sides. The lower edge of the glass "thus cut," was placed in a bed of putty, and the sides were caulked with oakum, over which putty was laid for waterproofing. The sizes are within 720 sq. ins. or practically within the requirements and recommendations of the National Board of Fire Underwriters, which specifies wire glass 24 x 30 ins. as necessary for efficient fire retardment purposes. I have not had any breakage reported. There are some cracks that I have observed, and which you will doubtless observe upon examining the premises, but thus far there has been nothing to warrant replacement. It may interest you to know of one experience which we have had, which would ordinarily result in a considerable bill for repairs. Some time since, in docking one of the large steamships, the wind and current drove the vessel against the outer end of the pier with sufficient force to knock the people off their feet and to break the flange of the water pipes which are laid upon the cross beams. The shock was felt at the landward end of the pier, and disturbed every person thereupon; there was no fall of glass and no damage or breakage sufficient to warrant replacement. Every inch of glass used in the piers to which I have referred to is ¼-in. wire glass in ribbed, mazed and polished patterns, and if I am called upon to undertake similar constructions, I shall use the same thickness of wire glass made by the Mississippi Glass Co., reducing the sizes to the Underwriters' regulations, and provide for the contraction and expansion of metal in which the glass is set by some kind of a flexible packing, which I shall make water-tight with putty.

In company with Captain Whittemore's representative we made a careful examination of the glass in the piers above referred to, and discovered very little breakage and no evidence of renewals. While there are no gases or smoke to contend with, the piers are subjected to extraordinary shocks and considerable contraction and expansion. One of the engineers accompanying us, explained that to overcome the contraction on the pier sheds, they had provided an expansion joint at the inshore end of the piers where they connect with terminal station. He also called attention to a light of glass in the terminal station from which the putty had been forced by the contraction of the metal frame without injury to the glass.

R. H. MACY & CO., DEPARTMENT STORE, NEW YORK.—We visited this establishment to examine glass installed there, and Mr. Clark, Superintendent, informed us that in the construction there was about 40,000 sq. ft. of wire glass used, of which 24,000 sq. ft. was used in the skylight construction. In making a careful examination of the skylights we found that it was ¼-in. wire glass, 18 ins. wide, 36 ins. to 72 ins. long. Mr. Clark stated that it had been in about two years, and there had been no renewals on account of breakage. There were, however, two lights of glass which looked as if they had been replaced, and three imperfect sheets of glass, two of which were broken and should not have been put in. These skylights are subject to severe atmospheric changes. The skylight frame is of metal construction and dome shaped.

NEW YORK SUBWAY KIOSKS.—Our attention was attracted to the number of these constructions on the streets in New York, and we examined those at 4th Ave. and 18th St., and were informed that there will be 1,000 of these exits and entrances to the subways, and that 600 of them are now in course of erection. They are of steel frame; the lower panels being of metal and the upper roofs and panels, canopies and partitions of wire glass ¼-in. thick. There will be used about 90,000 sq. ft. of wire glass in the construction of these kiosks. Those examined failed to show any breakage.

SOUTH TERMINAL STATION, BOSTON.—Captain Sanborn, General Manager, received your committee and accompanied it upon a tour of inspection, comprehending the train shed and the midway in which he stated there was installed 15,000 sq. ft. of "Besto" wire glass. The train shed covered 26 tracks, and is of steel construction, the skylights being of the monitor form, similar in arrangement to the Union Station at Pittsburg, Pa. All the glass is set vertically in wooden frames, covered with copper. Preliminary to our critical examination of the glass, Capt. Sanborn stated that it contained wire covered with asbestos which increased the bulk of the wire and decreased the coating of glass, and resulted in cracks admitting moisture which was retained by the asbestos coating until the wire expanded by rust or frost would cause the glass to scale and divide, making openings through which rain water found its way. There is a great amount of this breakage and a careful watch kept upon it. When a report is made that the glass is likely to fall because of disintegration, the light is removed and replaced with new wire glass, which is entirely satisfactory, and of which there are numbers of lights noticeable because of their being brighter and cleaner than the glass installed when the station was built about six years ago.

He also stated that the soft coal used on the 850 locomotives entering the train shed daily, generated gases which very seriously affected the exposed metal work inside the shed, as also the copper sheathing covering the skylight frames and the roof of the monitors. He stated that he knew of no means of preventing this injury. A careful examination of the skylight construction fully confirms Capt. Sanborn's statements. When asked the question: "If all the glass in the train

shed and midway of this station was blown out, and you were obliged to replace the glass with new, would you use hammered, ribbed or wire glass to replace same?" he replied, "I would replace it all with the same make of wire glass I now use for repairs." When asked the question: "Are you troubled with any great amount of leakage?" he replied, "Our train shed is dry, excepting in driving rain storms which result in water entering through the louvre." On being asked the question: "Is the broken glass which we observe due to the contraction and expansion of the metal superstructure?" Capt. Sanborn replied, "The glass in the monitors is set in wooden frames, and, my opinion, is that breakage results from the use of the inferior glass installed when the station was erected, combined with the tight fitting of the panes." Mr. Bugler, Engineer in charge of the South and Back Bay stations, was interviewed, and he confirmed the statements of Capt. Sanborn. In reference to Back Bay Station, he stated that the most serious question is one of ventilation. The trains enter this station from a subway. A fan system of ventilation was installed, which has proved very unsatisfactory. Mr. Bugler, when asked "When do you remove the cracked glass which we have noticed?" replied, "The cracked glass which you see is that with the asbestos covered wire in it; when it begins to bag and threaten to leak badly, or fall, we take it out and replace with plain wire glass."

BACK BAY STATION, BOSTON, MASS.—F. H. Tucker, Station Master, on being interviewed, stated that this station was completed five years ago. The skylights are of metal and glazed with wire glass in sizes ranging from 22 x 60 ins. to 22 x 72 ins. There are about 12,000 sq. ft. of wire glass in use here, and there have been no renewals or repairs. A careful examination was made of the skylight and there were discovered in the main skylight which contains 720 lights 22 x 60 ins., eight cracked lights which evidenced no leakage. In the skylights over the carriage entrances, the glass is about 22 x 72 ins. with no cracks showing.

These skylights are not subject to the gases generated by the locomotives which pass through the subway of this station. These skylights are subject to great wind pressure, due to the open ends of the building and heavy falls and drifts of snow, but sustained no injury.

On a visit to the Charlestown Navy Yard, Boston, Mass., we inspected the skylight construction of three buildings, two of which have been erected for some time, and the skylights in which contained 720 lights of 22 x 48 ins. ribbed glass; owing to the great amount of breakage, they are substituting wire glass. The other building, which is new and not yet occupied, contains 540 lights of 22 x 96 ins. wire glass. We might also state that in all other work where other than wire glass has been used they are substituting wire glass.

NORTH UNION STATION, BOSTON, MASS.—On a visit to the North Union Station, Boston, Mass., we called on Mr. G. H. Folger, Superintendent. He explained to us that the roof of a portion of their shed, covering 17 tracks and 350 ft. in width, when erected was of saw-tooth construction. The glass used in the skylights on this shed was American wire glass, the same as was originally used in Broad St. Station train shed, Philadelphia. They adopted this glass as a standard, but there being such breakage, they discarded this particular kind of glass, substituting "Besto" wire glass, the results of which were as unsatisfactory as those of the American wire glass, and in order to avoid leakage and accidents from the fall of broken glass, and provide for a better system of ventilating and lighting the train shed, they changed the construction of the roof, doing away with the saw-tooth construction, and installing monitors. These monitors are about 24 ft. wide, cover two tracks, and run the full length of the shed, about 600 ft. The glass in the sides of these monitors were set in sash, double hung, using plain American glass 20 x 34 ins. This system has been installed about two years, and has given entire satisfaction.

The remaining portion of the shed, covering the six remaining tracks, is a single span of about 134 ft. wide, similar in construction to that of Broad St. Station and contained "Besto" wire glass in the skylights. In making renewals of glass to these skylights, they put in wire glass of a smaller size. The lobby or midway, as they term it, running the full width of the train shed, has a series of skylights which are set with "Besto" wire glass 22 x 72 ins. In the renewals of these lights they are putting in glass of one-third the size, using wire glass. They also installed a system of fans which did not meet the requirements for ventilation, and they have abandoned them. They use coke and soft coal in their engines, and it has the same effect on their iron superstructure as we have found in other stations we visited. In fact, the gases from the coke are more injurious than those generated by soft coal.

UNION STATION, PITTSBURG, PA.—P. Cofrode, Master Carpenter, Pittsburg Division, states:

Glazing was completed on Union Station, Pittsburg, April, 1903. Since then to present date, four lights of glass have fallen. At the present time there are 15 glasses broken out. You will note there were only four fell out, the balance were removed by carpenters as they were badly cracked. At the present time there are about 50 lights broken. The cause of these glass lights being in this condition is due, I believe, to contraction and expansion. We do not have much trouble with the gable ends with the glass lights breaking out; the most trouble is in the monitors. The amount of glass in monitors is 13,600 sq. ft. As nearly as we can estimate the amount of glass in the gable ends is about 12,000 sq. ft. This is hammered glass, ¼-in. thick set in copper frames.

On our inspection of the train shed, Union Station, Pittsburg, we find the lighting and ventilating of monitor construction; 21 monitors to a side, one over each truss, and one over the center of each bay, and our observation fully confirms the statement of Mr. Cofrode.

The Westinghouse plant at East Pittsburg was visited to note conditions and kind of glass in the skylight construction. Two of the buildings were erected in 1895, and have hammered glass in the skylights. When renewals are required for breakage, wire glass is used. One other building 186 x 2,000 ft. long, completed in the latter part of 1903, has one half of the roof covered with skylight construction, in which they have used only wire glass set in frame. The results they have derived from the use of wire glass in preference to other kinds, has been entirely satisfactory.

Pittsburg and Lake Erie Station, Pittsburg, was visited in order to make an examination of the construction, condition, and kind of glass used in skylight of train shed. We found a train shed similar in construction to Broad St. and Jersey City, but of smaller dimensions. This shed has been erected about five years; the glass installed was originally "Besto" wire glass, but such a great amount of breakage resulted from the use of same that they removed it two years ago and replaced it with hammered glass set in copper bars, the results from the use of which have been entirely satisfactory; no wire netting is, or has been used under the glass.

We have also had brought to our attention a material known to the trade as "Translucent Fabric," but on investigation found it to be of so inflammable a nature that we gave it no further attention. We have also considered the utility of prism glass, but find that when darkened by smoke it would be valueless, and would require constant attention to keep clean. Mr. Thos. H. Johnson, Consulting Engineer, Pennsylvania Lines at Pittsburgh, was interviewed, and strongly recommends the monitor form of skylights.

CONCLUSIONS.—(1) That the gas and smoke from the locomotives because of its influence on the metal frame work of skylights, is the primary cause of the breakage of glass.

(2.) The contraction and expansion of the metal frame is also a serious cause of breakage where the glass is tightly fitted in the frames.

(3.) From the testimony elicited and from personal observations, we find the percentage of breakage in ribbed, hammered, and wire glass is about equal. We do not find that the breakage of wire glass results from any internal stress being set up by the contraction and expansion of the wire within it.

(4.) The larger sizes of glass break more readily than the smaller.

(5.) Glass set horizontally, or at angle, breaks more readily than glass set vertically.

(6.) Wire netting hung under glass, from the effect of gases upon it, is unreliable.

(7.) Wire glass is most desirable, because when fractured, the wire will generally hold it in position until repairs can be made.

(8.) Steel bars, such as used in skylights at Broad St. and Jersey City train sheds, because of the effect of gases on same, are unsatisfactory.

(9.) Wooden bars, such as used in skylights at Jersey City train shed, are desirable, being unaffected by gases. We recommend a zinc cap in place of the wooden cap.

(10.) We recommend that a zinc expansion bar be used with brass bolts in preference to wooden bars. We are led to this conclusion from the condition of the zinc cap on the skylights of Jersey City train shed, which shows no deterioration from effect of the gas.

(11.) We recommend that the sizes of glass used in skylights should not exceed 24 × 36 ins.

(12.) We recommend for future construction and present train sheds, where same can be adopted, a monitor form of skylight, preferably placed parallel with the tracks; of larger dimensions and increased height than that in use at Union Station, Pittsburg, set far enough apart so that one monitor will not obstruct the light of another; small sizes of glass, set in wooden or approved metal frames, frames set loose enough to overcome the contraction and expansion of the metal work of the shed.

(13.) We also recommend ventilating the monitors at the top, the opening being covered with an umbrella shelter, also by putting on each side of the monitor an opening under the eaves above the glass the entire length.

THE DESIGN OF CONCRETE STEEL ARCHES.*

By E. J. McCaustland.†

The use of concrete steel in arch construction is increasing rapidly year by year in spite of the fact that we have not a very great fund of clean-cut, definite knowledge as to the action of these combined materials under stress; particularly, in an arch ring subjected to moving loads. Arches are built, and carry the traffic for which they were designed with factors of safety ranging, probably, all the way from 3 to 150. In no other class of engineering work is "factor of safety" so truly and palpably a "factor of ignorance."

What we need now is not so much new theories, but a more careful study of old ones and a wider extension of our practical knowledge. What is the modulus of elasticity of concrete? How does it vary with the nature of the mortar or the aggregate, or with the quantity of water used in mixing, or with the ramming, or with age? What is a safe compressive stress for concrete and what is a safe tensile stress? These are a few of the practical considerations concerning which engineers hold widely differing opinions, and practice will vary as widely as the opinions. It is possible to get definite knowledge on these points, so that engineers may have a common point of starting in all matters pertaining to design?

The foregoing remarks are introductory to a brief abstract and discussion of a graduating thesis on "Steel Concrete Arches" offered by Mr. W. S. Edge of the College of Civil Engineering of Cornell University. In his paper Mr. Edge discusses briefly the ordinary methods of approximation in design, and calls attention to the well-known fact that the errors involved in the common assumptions of loading are such as to produce a very large element of uncertainty in any results that may be derived by subsequent computation.

The first point that impressed itself upon Mr. Edge when he began his investigation was the wide variation which exists in the current practice of proportioning the various dimensions of arch rings. He cites a particular case in which a certain railroad builds a 20-ft. concrete arch with a thickness at the crown of 36 ins., while another railroad, similarly situated, builds arches of the same span and practically the same loading with a crown thickness of 18 ins. The same wide variation in practice among all engineers who have designed arches, is manifest to anyone who gives the matter even the slightest attention. To make the relations more clear, however, Mr. Edge took the dimensions of a large number of existing structures designed for highway loading, and plotted them, using length of span in feet as abscissæ, and rise times crown thickness in feet as ordinates. This graphic representation, however, failed to show even the remotest indication of

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any law which might govern design or assist in proportioning the arch ring. Upon the same sheet he also plotted a curve representing the safe proportions for ordinary highway loading, as derived from his own designs, some 15 in number, the computations being based on the methods of Professor Cain. This curve is shown in Fig. 1.

The fundamental purpose of this investigation by Mr. Edge lies in an attempt to determine the most economical proportions of the arch ring, and also to investigate the elastic stresses under moving loads with a view of determining the position of loading which will make these stresses a maximum.

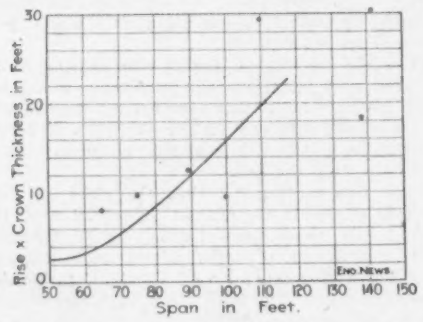

Fig. 1. Diagram Showing Dimensions of Actual Arches and Curve of Safe Proportions for Highway Bridge Loadings.

(Small circles represent arches which have been built; curve shows safe proportions for ordinary highway bridge loadings.)

The theory which formed the basis of the investigation is thus briefly stated:

(1) That, with an arch ring, given or assumed, and a uniform loading over the whole span, the crown thrust, considered horizontal, may be determined by dividing the half-span into, say, 20 parts of equal width and assuming the arch hinged at the springing.

(2) That this crown thrust should govern the thickness of the arch at that section.

(3) That if the neutral axis be made to conform to the equilibrium polygon for the case of symmetrical loading, and the thickness of arch ring be proportioned to thrust, no bending moment would occur.

(4) That reducing the load (i. e., making the load unsymmetrical) would reduce the thrust in a greater ratio than the stresses due to bending would be increased. Hence, at any time or section the stresses produced could not exceed in magnitude those for which the arch was designed.

(5) That the crown thrust determined by the approximate method as noted above will be the same as that determined by Cain's method.

(6) That the equilibrium polygon determined by the approximate method will conform closely to that determined by Cain's method.

These last two assumptions are not justified in the light of later work. In a test made of a 110-ft. arch for a rise of ⅛ of the span and loaded and designed for 100 lbs. per sq. ft. live load over the entire arch, Cain's method gave a thrust of 1.94% in excess of the approximate method, and the elastic polygon did not coincide with the approximate polygon by .03 ft. at the springing line.

In the preliminary designs the steel in the arch was not considered at all, it being assumed that for a correctly designed arch the metal would act only under eccentric loading, and this proved to be very nearly the case.

The following are the specifications and assumptions made in the work, following mainly the suggestions of Mr. Thatcher as reported in Engineering News of Sept. 21, 1899:

	Pounds per sq. in.
Modulus of elasticity of concrete	1,500,000
" " " " steel	30,000,000
Maximum stress on steel, tension	10,000
" compression on concrete	500
" shear on concrete	100
" tension on concrete	50

The above are exclusive of temperature stresses. The proportion of steel was such as to give an effective area of $^1/_{100}$ sq. ft. for each square foot of concrete. The steel ribs consisted of flat bars 2½ ins. × ¾-in. and were embedded in the concrete of the arch, spaced 2 ft. apart and at a distance of 0.1 ft. from intrados and extrados respectively. All designs were confined to highway bridges, of lengths varying from 20 to 200 ft.

Assumptions with regard to loading are as follows: Live load 150 lbs. per sq. ft.; depth of earth fill at the crown 1.5 ft.; weight of earth filling 100 lbs. per cu. ft.; weight of concrete 140 lbs. per cu. ft.

The form adopted for the intrados was a modified semi-ellipse; that is, a semi-ellipse slightly flattened at the haunches.

The first designs were made to meet the requirement of 150 lbs. per sq. ft. over the entire span, the general outline of procedure being as follows; rise and span being assumed, a semi-ellipse was drawn to meet the requirements of the intrados. Then the crown thrust was assumed and the ring roughly proportioned for an allowable stress in compression of 500 lbs. per sq. in. The half span was then divided into 20 equal horizontal subdivisions for the loading, and an equilibrium polygon passed by the ordinary method through the middle of the ring at the springing and crown. This, of course, determined the crown thrust for the assumed loading and involved a revision of the arch section, its form being changed at the same time to conform to the equilibrium polygon. Then the weights were recalculated and crown thrust redetermined and the arch section again revised, this generally giving as great accuracy as was desired.

Recurring now to the main portion of the investigation we recall the assumption that a linear arch ring proportioned to the thrusts which would occur under full load, would be well proportioned to withstand eccentric live loads; due to the fact that the thrusts would decrease even though the bending moments increased. To test the truth

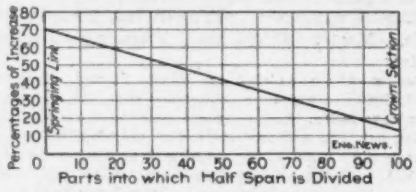

Fig. 2. Curve Showing Percentages of Increase for a Linear Arch Designed by Considering the Thrusts Due to Uniform Live Load.

of his assumption, investigation was begun of the stresses caused in an arch ring by the movement of a uniform live load of 150 lbs. per sq. ft. across the span. This load was continuous and was brought on from the left, occupying, in all, 16 different positions, including the case of no load and of full load. The arch was of 80-ft. span and 10-ft. rise, originally designed as a linear arch for uniform live load, by taking equal horizontal divisions. It was then redivided according to Cain's method into 48 sections in the whole span, and by means of shifting the load lines, the equilibrium polygons for different cases of loading were drawn and their ordinates scaled and tabulated.

It is not necessary to go into the detail of the computations performed by Mr. Edge, since Cain's method is well known to engineers. Suffice it to say that the work was very systematically arranged, so that most of the computation could be performed with a slide rule and quite rapidly.

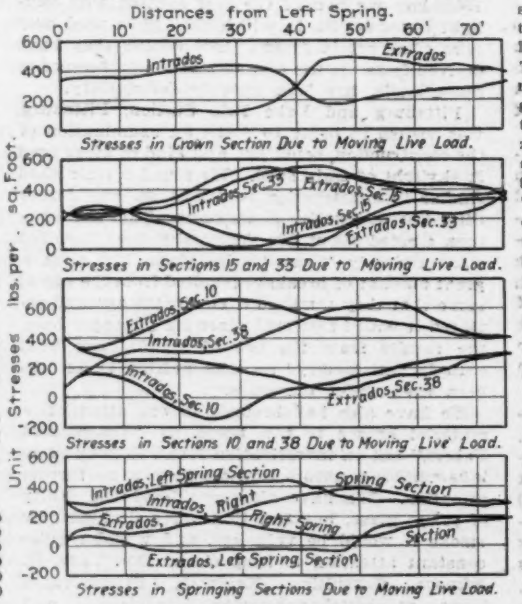
Distances from Left Spring.
Stresses in Crown Section Due to Moving Live Load.
Intrados
Extrados
Stresses in Sections 15 and 33 Due to Moving Live Load.
Intrados, Sec. 33
Extrados, Sec. 15
Intrados, Sec. 15
Extrados, Sec. 33
Stresses in Sections 10 and 38 Due to Moving Live Load.
Extrados, Sec. 10
Intrados, Sec. 38
Intrados, Sec. 10
Extrados, Sec. 38
Stresses in Springing Sections Due to Moving Live Load.
Intrados, Left Spring Section
Spring Section
Intrados, Right
Extrados, Right Spring
Section
Extrados, Left Spring Section
Unit Stresses lbs. per sq. foot.
Actual Arch Ring 80 ft. Span Rise 10 ft.
Part of Arch Treated 76 ft. Span Rise 7.52 ft.
Divided into 48 Sections by Cains Method
ENG. NEWS.
Successive Positions of Continuous Live Load Coming on from Left.

Fig. 3. Diagrams Showing Maximum Stresses at Various Sections of Arch Ring Due to Changes in Live Load.

Mr. Cain's formula for determining unit stresses in steel concrete was used, it being practically the same as that derived by Mr. Thacher and published in Engineering News.

After determining the unit stresses throughout the arch for the various positions of live load, the results were plotted in such manner that the curves would show the variations of stress, as the live load moved across the bridge, and the position in which the live load must be placed in order to determine the maximum stresses for any section of the bridge. In the first design of this arch the thickness was reduced to that required by the thrust alone, but it was soon determined that such proportion would give too light a section at the haunches for unsymmetrical loads. In other words, varying the thickness of the ring in proportion to the thrust at the section does not give a ring which is uniformly strong under a moving load, as the following diagrams show clearly that the maximum stresses are much larger at some parts of the ring than they are at others. By a series of trials using thrusts and moments already determined, Mr. Edge found that in order to keep the unit stresses down to 500 lbs. per sq. in., section 1 would require a thickness of 1.55 ft., section 10, 1.22 ft., and the section at the crown 0.95 ft. Now the thickness required at these sections was determined by considering only the maximum thrusts produced under full live load gave results as follows: Section 1, 0.910 ft.; section 10, 0.840 ft., and section at the crown 0.827 ft. This is sufficient evidence that there is a wide difference in the stresses set up in the arch by the changes in position of the loading aside from the question of the magnitude of that loading, the effect being especially marked at the haunches. From the values of the thickness of the ring as computed for various sections by the two methods, we may determine the percentages of increase that should be applied to the figures obtained in the preliminary design in order to meet the requirements of a moving load.

These figures are as follows:

At the spring lines	70.4%
At Section 10	45.3%
At crown	14.3%

Fig. 2 shows a curve for which these percentages are taken as ordinates and horizontal distances as abscissæ. From this curve the per cent. of increase at any section may be determined. The abscissæ of this curve are small parts of the half span and refer to no particular units. It is not expected that this curve will give results which may be used for all earth filled arches for different rises, especially higher ones, yet it is reasonable to suppose that it will give results fairly near the truth more quickly than any cut and try method can do. These large percentages show that it is not at all safe to proportion an arch ring to the thrusts produced by uniform live load, nor is it economical to design for uniform load over half the span.

The diagram, Fig. 3, shows the maximum stresses which may occur at various sections of the arch ring, due to a change in position of the live load.

Mr. Edge's conclusions are briefly summarized as follows: (1) That the graphic method of solution is as accurate as is justified by our knowledge of safe unit stresses in concrete. (2) That an arch ring designed for thrusts due to uniform live loading will be too thin at the haunches to resist stresses due to eccentric loads. (3) That in large spans it is more accurate to use Cain's method of subdividing the arch ring, since it gives in general, results for thrusts which are about 2% greater than will be given by dividing the arch into equal horizontal sections. Mr. Edge expresses the opinion that for spans up to 100 ft., the extra time required to perform the subdivision by Cain's method may be better employed. The equilibrium polygons obtained by the two methods of division are for all practical purposes the same, and therefore a linear arch by the approximate method will be a linear arch when investigated by Mr. Cain's method. (4) It is better not to try to use a modified semi-ellipse for an earth filled arch when the rise is less than ⅛ or possibly ⅛ of the span, as the equilibrium curve flattens it too much at the haunches. It is better to take full advantage of the rise by making the arch linear from crown to springing thereby reducing the crown thrust. (5) The maximum bending moment is not produced by a live load covering one-half of the bridge. For the crown section the bending moment is the greatest when the load is about three-fifths on the bridge. The greatest positive moment, however, occurs with the arch practically one-half loaded and takes place in section one. The greatest negative moment occurs when the arch is three-fifths loaded, and is found at section 48. (6) As the result of designing about 15 arches with spans ranging from 50 to 100 ft. and rises of from $^1/_{10}$ to ⅕ of the span, the following procedure is suggested as the most simple:

(a) Draw approximate intrados curve to meet the requirements of span and rise.

(b) Assume the crown thickness.

(c) Make a rough calculation of the weights and approximate crown thrust. With this value revise the arch section, the thickness of the ring at any section being roughly proportioned to the thrust at that section.

(d) Now, divide arch ring into at least 20 sections, and calculate weights of live load and arch ring for each section, and pass the usual equilibrium polygon through the mid points of the end section and the crown section; this will change the crown thrust and necessitate a slight revision of the arch section. When this is made, the form of the arch ring is slightly modified to make the equilibrium polygon coincide with the neutral axis. Then the arch ring crown and spring thickness should be increased by the percentages, which may be taken from Fig. 2. The final equilibrium polygon, being passed through the centers of these reduced sections, becomes the neutral axis for the arch. The rest of the ring is then constructed

upon this curve, the sections being increased by the percentages given on Fig. 2.

This gives the arch in its final form and any revisions that it may need are bound to be trifling. Such design should be correct for all street car loading, but if desired to investigate the actual conditions of stress in the arch, it may be done by assuming the amount of steel in the ring and then following Cain's method to determine from maximum bending moment whether or not there is enough steel present. (7) It is evident that the steel concrete arch designed to keep the equilibrium polygon within the middle third is needlessly strong, for in one case the polygon was 0.44 ft. eccentric, while it should not have been more than 0.26 ft. from the neutral axis to have been inside the middle third. (8) By using the values (Fig. 1) for crown thickness, the ring may be proportioned but should be made linear, and if made so, it will actually require less revision than if it were designed by the method first suggested.

It will be noted that item (d) of method of procedure advises a design by the ordinary approximate or static methods, and item (e) suggests an investigation of the design thus made by considering the elastic properties of the material. This is probably the best that can be done under the circumstances. Cain's method is based primarily upon conditions of equilibrium which are adapted to investigation only and not to design. Hence, some simple approximate method of design is needed and the most obvious procedure is to take advantage of any relation that may exist between thrusts due to uniform live load and stresses produced by eccentric loadings. If it can be established that such relation exists and its nature determined, a long step will be taken in the right direction. The foregoing investigation by Mr. Edge is restricted of course to a single span rise and loading.

The results are here given, however, in the hope that some one else may be interested in extending the investigation to other spans with different loadings.

A KEROSENE HOISTING ENGINE.

Steam hoisting engines, owing to their intermittent action, consume an undue amount of coal for the work actually performed. And to this fuel loss, arising from the necessity of keeping up steam pressure though the engine may be working only one-tenth of time, must be added the further loss of heat by constant radiation from the boiler and engine.

With an engine operated by kerosene or gasoline, however, fuel is only consumed when the engine is in operation, thus saving in fuel; and there is no delay in "firing up," as in the usual type of boiler and steam engine. For these reasons there seems to be a promising field of usefulness for the kerosene and gasoline engine for contract work; and scores of concrete mixers are now driven by oil engines, the earlier types being now so improved that they are excellently adapted for intermittent work.

A kerosene hoisting engine is now manufactured by August Mietz, 128 Mott St., New York, that is stated to be giving perfect satisfaction after eighteen months' trial. The engine seen by our representative is used in hoisting barrels of crude oil and is installed on a barge. Engines of this type, ranging from 2 HP. to 30 HP., are employed for various purposes, such as driving threshing machines, water and air pumps, etc. Their adaptation to driving portable stone crushers, to concrete mixers, and other contract use where an engine of moderate power is required, is a matter of detail, and they should certainly be received with favor among contractors.

THE UNION ENGINEERING BUILDING project has progressed to the point where competitive plans are to be called for from half a dozen leading firms of architects. The following have consented to join in the competition: Carrère & Hastings, Clinton & Russell, Whitfield & King, Ackerman & Partridge, Palmer & Hornbostel and Lord & Hewlett. The committee will have the advice of Prof. W. R. Ware in the conduct of the competition. In addition to the six competing firms, each of whom will be paid for its plans, there will be an open competition in which the leading competitors will be compensated by four prizes.

A PROCESS FOR PREVENTING THE GROWTH OF algae in potable water has been developed by the Bureau of Plant Industry of the Department of Agriculture, and will shortly be given to the public in a bulletin of the Department. The newspaper reports of the details of the process which have been published within a week or two, we can state to be premature and unauthorized. The importance of any process which will effectually prevent the growth of the organisms which give rise to the cucumber taste in water is well known to all engineers familiar with water supply problems.

A BY-PRODUCT COKE OVEN PLANT is being erected at Milwaukee, Wis., by the Milwaukee Coke & Gas Co. The ovens are of the Semet-Solvay type, and 40 are now completed while 40 more will soon be ready. Coal is unloaded from vessels by Brownhoist unloading machines, and piled on the company's dock or loaded directly into 50-ton steel cars, which dump into the hopper of a link-belt conveyor. This in turn feeds the hoppers from which the coal is deliverel into the charging larries; these run over the top of the ovens, each oven having three charging holes, so that the charge may be well distributed. The coal is then leveled off by hand from the end of the oven, a long rabble being used for this purpose. When the coking is completed the charge is pushed out by an electric ram, and is struck by a stream of water from above, the coke falling into a quenching car on a track below the oven doors. Southern coal is used, and the product is used for domestic and foundry work. The 80 ovens will produce about 450 to 500 tons of coke per day, and as there will be a surplus of some 3,000,000 cu. ft. of gas daily, beyond what is required for heating the ovens, the company has asked the city for a franchise to lay pipes and distribute gas.

WATER METERS at Battle Creek, Mich., are applied to 87% of the services. The total quantity of water pumped in 1903 was over 468,000,000 gallons and it was distributed as follows, according to the report of the Superintendent, Mr. W. W. Brigden:

	Per cent. of whole.
Paid for by meter at 10.2 cts. per 1,000 gallons..	58½
Paid for, not metered	6
Parks, public buildings, etc., except schools...	7
Schools, including lawns.....	5
Drinking fountains for horses.....	5
Flushing sewers	½
Blowing off hydrants.....	½
Wetting down trenches, sewer, water, etc.....	1
Fires	4
Slip of Pumps	3
Non-registration of meters.....	3
Leaks	6½
Total	100

It will be seen that about one-fourth the whole quantity pumped is used for various public purposes for which no charge is made.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Erie Ry. near Scranton, Pa., on April 15. A cut of loaded freight cars ran away down a grade and collided with a double-headed freight train going up grade. Three trainmen were killed in the wreck.

A BAD STREET RAILWAY ACCIDENT in Santa Barbara, Cal., on April 11, resulted in the death of five passengers. A heavily loaded car coming down a steep grade failed to respond to the brakes, and on reaching a curve it left the track and was wrecked. The coroner's jury found as follows:

That the decedent came to his death by the breaking of the brake-beam casting on the car, whereby the motorman lost control of the car, which turned over at the corner of Garden and Mission Sts., in the city of Santa Barbara, and we do hereby exonerate the conductor and motorman from any criminal liability.

The car was equipped with both air and hand brakes, and both of these were used in the attempt to check the car's speed, without effect.

A POWDER EXPLOSION IN THE AFTER TURRET of the U. S. battleship "Missouri" on April 13 killed 32 men; in fact, all who were in the turret and all but one or two of those in the supply room below. The explosion of the ammunition magazine was narfowly avoided. The vessel was at target practice off Pensacola, Fla. The 12-in. gun in the after turret had already fired a number of rounds and was just being reloaded when a part of the charge in the breech exploded. The charge for a gun of this kind consists of 360 lbs. of smokeless powder, in four bags. The four bags for one charge were in the turret, or one or more of them may have been in the breech, when through some cause, either a spark left in the breech or a blow-back of flame, the powder was ignited. Several charges of powder were lying in the supply room below the turret, and these were ignited by burning matter dropping down the hoist-way. This second explosion was more serious than the first, and probably the entire loss of life is due to this explosion. It is rumored that the magazine door leading into the supply room had been open, but that after the first explosion one of the men closed this door, thereby saving the ship. It is said that a strong adverse wind was blowing at the time of the explosion. It is recalled also that there has been much competition among the battleships of the U. S. Navy for the speed-record in firing large guns.

THE BOONTON DAM ACCIDENT, noted in our last issue (p. 351), resulted in the death of the diver who was caught in the opening of the outlet pipe. His body was recovered on April 15, four days later. Various attempts had in the meantime been made to release him, but none succeeded except the slow method of replacing the broken valve stem of the disabled gate valve, which made it possible to close the valve and thereby stop the rush of water which first caught the unfortunate diver. The depth of water on the diver was some 60 to 70 ft., corresponding to a pressure of about 30 lbs. per sq. in. It is believed that his death was only in part due to prolonged stay in this pressure, since it was found that in one attempt to pull him out the diving suit had been torn so as to partly fill the helmet with water when the diver was lying down. The disabled valve was repaired through the valve well, by filling this well with water, removing the valve cap and replacing the stem.

RAILWAY TRAIN ACCIDENTS in Great Britain in 1903 caused the deaths of 25 passengers and the injury of 769. This includes only accidents to trains. Other accidents, in which the passengers' own misconduct or carelessness were involved, caused a far greater number of casualties. For example, 25 persons were killed and 137 injured by falling between cars and platforms at stations, and 13 were killed and 1,021 injured by falling on the platform or track in getting on or off trains. The side-door entrances of English cars appears to be responsible for a considerable number of accidents, as 430 persons were injured by the closing of car doors and 38 were killed and 74 injured by falling from cars while the train was in motion.

A DEVICE FOR PROTECTING A DERAILED TRAIN is reported by Richard Guenther, U. S. Consul-General at Frankfort, Germany, as having been invented by Mr. Gehricke, a German railroad officer. The description given is as follows:

A rail is adjusted to the truck of the car parallel with the axle, so that it is in a position across, and about an inch above, the rails. Should a derailment of the wheels take place, these cross rails will lie upon the rails of the track without letting the wheels touch the ground. The car will then drag along upon the cross rails and slowly stop the whole train. In order to break the force of the settling of the car as much as possible, the cross rails are so adjusted that they are as near as possible to the rails of the track and are, in addition, supplied with springs. The cross rails are also supplied with projections underneath for the purpose of preventing the car from leaving the track.

COAL STORAGE BINS should be so designed that fire occurring in the coal from spontaneous combustion will not wreck the bin itself. In the March report of the Boston Manufacturers' Mutual Fire Insurance Co., a description is given of a fire at a paper mill at Grand Mere, P. Q., which is instructive to engineers responsible for the safe storage of coal. We print it as follows:

About the last of November, the coal pile at boiler house No. 2 was found to be on fire near the trestle. The pile consisted of about 6,000 tons from the Old Sydney Mine, Cape Breton, and was put in last fall after the storage space had been cleared of all old coal. This coal pile was located in a peculiar situation and it was very difficult to handle the coal in an attempt to control the fire. The coal was delivered by cars on a trestle 20 to 40 ft. high, located about 90 ft. north of the boiler house. From the cars it is dumped on a steep ledge, where some of it remains, but a considerable part rolls down into a pocket blasted out of the ledge back of the boiler house, where it piles up 25 ft. high against the brick wall of the boiler house, which is reinforced by steel I-beams built into the wall vertically 6 ft. apart, and the tops of the beams anchored to the ledge at the rear by 1½ in. iron rods.

Fire was first discovered in the upper portion of the pile near the trestle, and some of the timbers of the trestle were damaged before the coal could be moved. The most serious part of the fire was in the deepest part of the pile close to the boiler house, where it burned so that the iron anchor rods holding the boiler house wall gave way. This allowed the wall to bulge inward several inches in places, and it had to be shored up on the inside with heavy timbers to prevent falling in. It took several weeks to use the coal that was burning, and only a small amount could be removed on account of the exceptionally difficult location. It is estimated that about 1,500 tons actually burned up.

A section of wall about 86 ft. long averaging 36 ft. high will have to be rebuilt. It is advised that, in rebuilding, the wall be constructed of steel-concrete with counterforts to reinforce it.

THE LEWIS AND CLARK EXHIBITION at Portland, Ore., in 1905, will celebrate the centenary of the expedition of these explorers across the great northwest, which led to the acquisition by the United States of the Oregon territory, which is now divided into Oregon, Washington and Idaho. The acquisition of this territory was a supplement to the purchase of the great Louisiana territory in 1803, and extended the United States possessions to the Pacific Coast. The site of the exhibition is a tract of 185 acres of land and 385 acres of wafer about two miles from Portland, at the junction of the Columbia and Willamette Rivers. The general treatment of the site was planned by Olmstead Brothers, of Brookline, Mass. Roads have been built, sewers and drains built, and a water supply system installed, the total construction expenses up to February last being about $100,000. There will be about seven main buildings, approximately 450 × 200 ft. The management is in the hands of a corporation: President, H. W. Scott; Director-General, H. W. Goode; Director of Works, Oscar Huber; Director of Architecture, Ion Lewis.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see pages* 26-27. *New copy for standing advertisements should be received ten days in advance of publication; new advertisements, Monday morning. The pages containing "Want" advertisements are held open until Tuesday, and those with "Proposal" and "For Sale" advertisements until Wednesday at* 11 *a. m.*

The record of experience with trainshed skylights, which we publish elsewhere in this issue, is deserving of serious attention by railway officials. Briefly stated, this record shows that no form of skylight construction gives enduring service when subjected to the exacting conditions of load and temperature stresses, aided by corrosion, which exist in large trainshed roofs. It demonstrates, moreover, the very important fact that failure is not a question of using one or another kind of glass, but is due to the distortion and destruction of the framework that supports the glass. In a word, all forms of metal skylight frames crumble to pieces under the steady attack of locomotive gases and the constant push and pull of temperature movements in these large closed roofs. As might be expected, certain forms of skylights, and certain kinds of glass have given better service than others but none has endured more than a small fraction of the total life of the structure of which it forms a part. These briefly, are the facts presented by the record which we publish, and they lead only to one conclusion.

To get entirely away from the difficulties which have been cited, a revolutionary change in trainshed construction is necessary. The closed shed with a lofty single span steel roof must be abandoned, and a return made to those constructions which permit ample lighting by monitor roofs, or which provide simply for covering the passenger platforms by umbrella roofs. These are somewhat bold assumptions, but we feel confident that a careful study of the question will prove their truth. The destruction which is being worked by corrosion in skylight frames with such rapidity that their life is counted in months is just as certainly being wrought in the great steel arches and roof trusses. It is only a question of time when they, too, must be renewed, and if report and observation go for anything, this time is not very far distant for several of the monumental structures built within the last ten years. If our trainshed roofs must be rebuilt once or twice in a generation good engineering dictates that they shall be so designed in the first place that reconstruction will be as easy and inexpensive as practicable, and this desideratum is not met by single span wide arch roofs. The problem is best solved by the umbrella roof over platforms only. In this construction we have almost ideal freedom from corrosion and the very cheapest construction of which the conditions permit. Its great objection is that it affords only a partial protection from the weather and is, therefore, not so comfortable for travelers who arrive and depart by train during stormy weather. If closed trainsheds cannot be abandoned entirely, then they should be constructed with roofs made up of several spans supported on columns between walls. With careful design, all the necessary light and ventilation can be secured by monitors and the replacing of corroded members becomes a practicable and comparatively simple process.

The real objections to extremely dry air in artificially-heated buildings, particularly in those heated by hot-air furnaces, do not seem to be grasped by at least one of our readers. This particular engineer takes exception to the general attitude of the discussion of the literature of this subject which appeared in our Engineering Literature Supplements for Nov. 12, Dec. 10 and Jan. 14. He argues that because the putrefaction of dead animal matter is rapid in moist, dry climates, and is virtually absent under the scorching, rainless skies of some parts of the Southwest, therefore we should aim for a low rather than a high humidity within doors during our Northern winters. But none of us care to be turned into either dried meats or mummies, even though it might prolong corporeal existence for some scores or centuries of years. Seriously, what our correspondent fails to appreciate is the difference between (1) a practically continuous life in a very hot, dry, and pure outdoor air, as in the Southwest, and (2) an alternation between the more or less crowded, over-heated and very dry atmosphere indoors and a relatively high humidity, combined with low temperature, outdoors. The relative physiological effects of conditions (1) and (2) have never been scientifically recorded and discussed, on a large scale, so far as we are aware. Sunlight and free-moving air are nature's greatest disinfectants. These abound on the plains of the Southwest, and both temperature and humidity are relatively constant there for long periods of time. In case of artificially-heated, buildings, particularly in northern cities, sunlight and free-moving air are at a minimum, and without these a hot, dry atmosphere, up to the limits of house conditions, has relatively little bactericidal effect. On the other hand, extreme dryness of house air, with sudden changes to outdoor conditions, is apt to be a severe strain on the whole respiratory tract, and to give rise to irritation or other conditions favorable to the development of the pathogenic germs which so frequently find access to the respiratory system.

It must be admitted that such means as are ordinarily provided to increase the humidity of buildings during cold weather are inadequate and unreliable. Elsewhere in this issue may be found a description of an apparatus designed to effect automatic control of the humidity of public buildings and large residences. The device is ingenious, is now used quite extensively, and certainly merits consideration.

The danger of fire in a pipe gallery system is discussed by our contemporary, "The Electrical World and Engineer," in connection with a recent fire in the Rapid Transit subway excavation under lower Broadway. The fire occurred in the section which is now being constructed under a wooden roof covering the entire street surface and was caused in the following manner: A great number of electric cables containing wires for telephone, telegraph, electric light and power and fire alarm signal service were buried in ducts beneath the street service. In the process of excavation the removal of these ducts was necessary and temporary supports were provided for the cables, which were wrapped in burlap. Two electricians were at work making repairs or alterations among these cables, using gasoline lamps for soldering. One of these lamps set fire to the inflammable burlap, and the fire was quickly fed by the mass of wood adjacent and by the insulation of the cables. The electricians and the gang of excavators in the subway had to run for their lives. The fire department soon put out the blaze, but the lead coverings of the cables had been melted and it was a work of days to repair the damage during which telephone and other service to the district supplied by these cables was largely cut off.

Our contemporary above referred to, thinks this accident must tend to put the advocates of pipe galleries on the defensive. It says:

> This accident has been regarded as an argument in favor of pipe galleries, but it seems to us that this is a view of the case hardly justified by the facts. If these telephone and telegraph cables had not been disturbed from their normal location, they would have been enclosed in the usual fireproof brick manhole and in fireproof ducts. The cables would have been stood neatly against the walls of the manhole and would not have been surrounded by inflammable burlap and by the mass of woodwork which fed the flames. Now, in most of the pipe gallery schemes which have been discussed from time to time, the plan has been broadly that of carrying the cables in masses through an open tunnel, thus exposing them throughout their entire length to the danger of just such an accident as that which has occurred and which will inevitably occur again unless greater care is taken.
>
> Another view of the pipe gallery question suggested by this accident brings up, apparently, a danger of the first magnitude. If in such galleries there should also be carried with the electrical conductors enormous gas and water mains with their various connections, the liability to fire, flood and explosion would appear to be seriously enhanced. With a big gas pipe broken, the gas rushing forth in vast volume and mixing with the air in the pipe gallery would, if ignited, as it undoubtedly would be, cause a pretty lively concussion. On the other hand, the bursting of a water main might drown out like a lot of rats the passengers in nearby subway trains before they could be extricated.

We fully agree that the Fulton St. fire is a useful object lesson in connection with the pipe gallery question, but to us it seems rather to point out how to avoid danger in such galleries than to cast discredit on the whole system of pipe galleries. Inflammable wooden supports and burlap wrappings would certainly be rigidly excluded from a pipe gallery system and no combustible material should be used in such galleries except the necessary electric cable insulation, which would be protected by the usual lead covering.

As for the leakage of gas in such galleries, it would doubtless be necessary to provide a complete system of ventilation for them, as is now done with the existing electrical subway ducts. Such a system would remove the gas leakage as fast as it occurred. All pipes and their joints in such a gallery would be open to inspection and repair so that the leakage from both gas and water mains could be reduced to a very trifling amount. Our contemporary speaks of big gas pipes breaking; but there is no reason apparent why such pipes should break. They are not subject, like steam or water pipes, to high pressure, but carry gas at a pressure of only a few ounces. Breakages do sometimes occur in such mains laid in the earth through unequal settlement, or pressure of the earth fill over them; but all such causes of breakage would be absent in a pipe gallery.

As for the picture of a bursting water main drowning like rats the passengers in the adjacent Rapid Transit tunnel, we may remark that in so far as this may be considered a danger, it would be quite as great if the water mains were buried in the earth alongside the Rapid Transit tunnel, as it would be if the mains were in a pipe gallery adjacent to the tunnel. It is not now proposed, so far as we recall, to place water or gas mains in the Rapid Transit tunnel itself.

We intend, by our comments, no depreciation of the importance of the question raised by "The Electrical World." On the contrary, we believe it is highly important that questions of this sort should receive serious consideration. To design and build a pipe gallery system on even a small scale without attention to the dangers which may be created, might readily lead to some disaster which would seriously retard for many years the general introduction of the pipe gallery system. It may be that fireproof bulkhead walls ought to be provided in a pipe-gallery system; by which the effect of fire, or gas, or water leakage would be confined to the section on which it originated and thus be more readily handled.

In the same connection we may make reference to an idea, which we believe was brought forward in this journal years ago; but which is sufficiently meritorious and important to again be presented. It is merely the construction of underground chambers at each street intersection. It is well known that the cost of pipe galleries

through the entire length of a street reaches an appalling sum per mile, sufficient to place the system beyond the reach of any save the most densely populated and wealthiest cities, and in these cities only in certain limited districts. At street intersections, however, the manholes for water, gas and electric mains in many cases fill nearly the entire space under the street surface, and actually have cost more to construct than would be required to excavate the entire area included in the street intersection, roof it over and wall it about. The cost of such chambers would be a very small fraction of the cost of a complete pipe gallery system, and they would afford to a large extent the same advantages. Such pipe chambers would be free from the objections raised by our contemporary, and if properly ventilated and inspected, it would seem that they should be at least as safe from danger of fire, flood or explosion as the existing subway systems.

A good idea of the growing importance of the newer types of prime mover, the gas engine and the steam turbine, is furnished by the statement of the U. S. Consul at Chemnitz, that in Germany the depression in the steam engine trade is ascribed to the increasing use of gas engines and steam turbines. Of course, the business depression now ruling in Germany is also an important factor; but the extending use of the rival types of motive power cannot fail to have an effect on the business of established steam engine builders.

It is doubtless a forecast of similar conditions in this country which has led at least one very prominent firm of steam engine builders in the United States to take up steam turbine and gas engine construction.

A SCHEDULE OF GENERAL CLAUSES TO BE USED AS A GUIDE IN DRAWING SPECIFICATIONS.

Errors of omission are so common in specifications as to make imperative some means of carefully checking the written specifications before publication, if the author would make sure of their completeness and sufficiency. The errors that occur most frequently are omissions of one or more general clauses. By general clauses we mean those clauses that without material change may be used as a part of any specification for any engineering work. A few general clauses, it is true, are especially applicable to certain classes of contract work as, for example, maintenance clauses in city contracts and freight clauses in railway contracts.

The few published schedules of general clauses are noteworthy for their omissions, rather than for their completeness. Doubtless they have served satisfactorily for certain particular classes of work, but whoever makes an analytical study of large numbers of specifications written by engineers, whose collective experience is certainly a better guide than any individual experience, must be struck with the number and variety of instructions, provisions and restrictions that engineers have thought wise to insert as general clauses in their specifications.

It is true that the general clauses are not always separated and grouped by themselves in specifications as we find them. This failure to segregate the general clauses appears to us a mistake, and is itself accountable for many omissions. In compiling the schedule of general clauses given herewith, we have endeavored not only to present a list that will be tolerably complete, but have tried to group the clauses under headings which in a general way will indicate the character of the clauses. There is difficulty in satisfactorily grouping any such heterogeneous collection of clauses, and it is also not easy to draw the line between single clauses and compound clauses. In the actual writing of specifications it is not necessary to assign a separate paragraph to each of the 120 clauses that are here listed, even if all of them were used; but in order that no important provision may escape unnoticed it is well to number each provision as we have done, for the purpose of checking the written specifications. In writing each general clause, any desirable number of these 120 single clauses may be grouped together.

Not every one of these 120 clauses is to be commended either as wise or as necessary, but this phase we do not intend to discuss at this time Moreover, others will differ with us as to the wisdom of using or of not using certain general clauses, and our aim is to secure completeness in number rather than excellence in quality in this schedule. With this end in view, we invite our readers to send us any general clauses which they have found of value, but which are omitted from this tentative schedule.

Schedule of 120 General Clauses.

INSTRUCTIONS TO BIDDERS.

1. Blank bidding sheet to be filled in with both words and figures for each item.
2. No alterations or restrictions to be made in bidding sheet or specifications.
3. Sheets must not be detached.
4. A copy of advertisement must be attached to bidding sheet.
5. Each bidder must sign his full name and address. If firm name is signed, names of members must be given; if corporation, names of officers.
6. When signing for another person, power of attorney must be filed.
7. Bid must be sworn to before a notary.
8. One man interested in two bids will cause their rejection.
9. Bid must be accompanied by certified check or draft of —— % of amount of bid (or of $——).
10. Conditions of return of check, and of its forfeiture.
11. Amount and kind of bond required (personal or surety company). Member of firm not accepted as bondsman for firm, or vice-versa.
12. Contract to be signed and bond given in — days after notice of award.
13. Samples of materials and names of manufacturers to accompany bid.
14. Bidder must examine site of work.
15. Bidder should be present at opening of bids.
16. Bids must be balanced, no prices unreasonably low or high.
17. Bids may (or may not) be withdrawn after filing and before opening.
18. Bids must be in triplicate (if required).
19. Bids must be sent in sealed envelope addressed to ——— and indorsed on the face with name of work and date of opening of bid.
20. Bidder must be prepared to present evidence of experience, ability, and financial standing, sworn to before notary; as well as statement as to plant and machinery.
21. Bidder required to state number of days required to complete work, and for purposes of comparing bids each day will be assumed as worth $——.
22. City (county or state) not responsible for information furnished by officials, excepting Engineer. In case of doubt ask Engineer as to plans and specifications.
23. Expense of executing contract, including notary fees, to be paid by contractor.
24. Plans and specifications may be seen at ———.
25. Bids will be opened at ——— by ——— on ———.
26. Contract will be awarded to lowest responsible bidder.
27. Right reserved to reject any or all bids.
28. These instructions are a part of the contract.

GENERAL DESCRIPTION OF WORK.

29. Work is located at ———; involves principally the following items: ———.
30. The funds available are $———.
31. The work is governed by the following ordinances (statutes or laws): ———.
32. Laborers must be citizens, paid not less than $——. for ——hours work; payments made weekly.

TIME OF BEGINNING AND COMPLETING.

33. Work must begin ——days after notice of award.
34. Progress and completion clause.
35. Penalty and bonus clause for non-completion.
36. Extension of time; (a) due to strikes; (b) stoppage by order of engineer; (c) stoppage by weather, and (d) for other specified reasons.
37. Extension of time does not release bondsmen.
38. Conditions of final acceptance.
39. Right to suspend work; no claim for damages in consequence of suspension.

PAYMENT FOR WORK.

40. Partial payments; —— % retained till completion (see Clause 118).
41. All work itemized in bidding sheet to be paid for at prices bid, which prices include: (a) bailing and draining; (b) snow and ice removal; (c) coffer damming and pumping; (d) sheeting and shoring; (e) care and support of pipes, sewers, building and other foundations, electric wires, etc.; (f) false-work, centers, forms and molds; (g) clearing and grubbing; (h) cleaning up and removal of debris; (i) plant, tools, fuel, etc.; (j) protection fences, guards, lights, etc.; (k) temporary bridges, roads and walks; (l) roads and tracks for conveying materials; (m) and all other classes of work and materials required to finish and deliver the completed work and structures designated by items in the bidding sheet.
42. Extra work clauses: (a) what constitutes extra work; (b) force account work plus percentage for profit; (c) price determined by Engineer; (d) price determined by board of arbitration; (e) no claim recognized unless filed in writing within —— days after ——; (f) bondsmen not released by extra work.

DEFINITIONS.

43. Board of Arbitration.
44. Contractor.
45. Council.
46. Engineer.
47. Inspector.
48. Engineering Terms, such as: (a) Force-main; (b) house connection; (c) lateral; (d) main; (e) submain; (f) material delivered; (g) neat lines (see also Measurements).

INSPECTION.

49. Duties of inspector.
50. No inspector furnished for gang of less than —— men.
51. Work done in absence of inspector subject to rejection.
52. Contractor to provide facilities for inspection.
53. Contractor to provide laborers to assist during inspection.
54. Culled material to be removed at once.
55. Contractor to make openings or tear out work for inspections; conditions of payment for such openings.
56. Acceptance by inspector not final.
57. Contractor to pay for inspection (during work or after expiration of time limit?).

SPECIAL DUTIES OF CONTRACTOR.

58. Contractor to give his personal attention.
59. Contractor to have representative who can act upon special orders.
60. Contractor to have office at ———.
61. Contractor to keep plans and specifications on the work.
62. Contractor to co-operate with other contractors.
63. Contractor to furnish the following: (a) laborers to assist Engineer in setting stakes, in sounding, etc.; (b) laborers to assist Inspector in handling materials; (c) materials for stakes; (d) boats to convey engineers; (e) scales for weighing materials; (f) offices for engineers; (g) board and lodging for engineers and inspectors at $—— each per week.
64. Contractor must preserve stakes, bench marks and monuments (penalty provided).
65. Contractor must secure permits and licenses.
66. Contractor must study and obey rules and regulations of city fire, water, park and police departments, with special attention regarding hydrants, steam boilers, use of explosives, protection of trees and shrubbery.
67. Contractor must provide earth-closets for laborers.
68. Contractor must furnish bills of lading to Engineer when requested.
69. Contractor must show time books for work done on force account.
70. Contractor must employ a graduate civil engineer (if character of work requires it.)

CONTRACTOR'S LIABILITIES.

71. Contractor liable for accidents to persons or property.
72. Contractor liable for injury to work by the elements.
73. Contractor must insure against fire.
74. Contractor liable for unforeseen difficulties in performing the work.
75. Contractor must preserve and protect materials and finished work until final acceptance.
76. Contractor must verify borings and soundings.
77. Contractor must verify plans.
78. Contractor must check and verify bills of materials furnished by Engineer.
79. Contractor must verify lines and stakes set by Engineer
80. Contractor must assume all liability for patent royalties.
81. Contractor must pay demurrage on freight.
82. Contractor must pay all freight on plant and materials (on railway contract).
83. Contractor must pay for all water used.
84. Contractor must pay for rental of city plant (steam roller, etc.) at specified rate.
85. Contractor must dispose of all surplus excavation, old materials, etc., not claimed by city or abutting property owners.
86. Contractor to provide means for public travel.
87. Contractor's liabilities not affected by sub-contracting.

CHANGE OF PLANS AND INTERPRETATION OF PLANS.

88. Change of plans, grades, etc., may be made by Engineer.
89. Change of plans will not release bondsmen.
90. Quantities may be increased or diminished without limit (or within a limit of ——%).
91. Written matter to prevail over printed matter in specifications.
92. Engineer (or Board of Arbitration) to interpret plans and specifications.
93. Plans and specifications to be taken together.
94. Omissions not to be used as excuse for non-performance or extra price.
95. Complete workmanlike job required.
96. Quantities and sufficiency of plans and specifications not guaranteed.
97. Soundings not guaranteed.

MEASUREMENTS.

98. Measurements made of actual lengths, areas and volumes within the "neat lines."
99. Units of measurement defined, such as: (a) "square"; (b) sq. yd. (9 sq. ft.); (c) cu. yd. (loose or solid?); (d) acre of clearing and grubbing; (e) lin. ft of sewer; (f) ton (2,000 lbs.); (g) mile of track; (h) lin. ft. of piles "delivered"; (i) ditto "driven"; (j) M. ft. B. M.; (k) day (24 hrs. or 10-hr. shift); (l) 1,000 brick (how counted or estimated); (m) barrel of cement; (n) "parts" (by volume or by weight?).

CONDUCTING THE WORK.

100. Plant shall be delivered, how, where and when.
101. Plant must not be removed after delivery.
102. Materials shall be delivered, how, where and when, and how stored or piled.
103. Work shall begin at places designated by engineer, and as herein specified.
104. Contractor may build storage sheds, etc., in street.
105. Right of way will be furnished to contractor.
106. Work shall not be done on Sundays or legal holidays (nor at night?)
107 Workmen's quarters.
108. Sale of liquors to and use of liquor by laborers prohibited.
109. Engineer may require discharge of employees.
110. Skilled mechanics must be hired.
111. Subletting prohibited except by permission.

MAINTENANCE.

112. Maintenance required for —— years.
113. Maintenance defined.
114. Failure to repair during maintenance period.
115. Maintenance bond or cash deposit.
116. Provision for disturbance of the completed work by others than the contractor.

COMPLETION AND ABANDONMENT.

117. Contract canceled by default.
118. Contract abandoned.
119. Contractor's sworn statement required on completion of work.
120. Receipted bills, satisfied liens and other evidences of non-indebtedness for materials and labor must be filed with Engineer (see also Clause 38).

LETTERS TO THE EDITOR.

Durability of Iron Imbedded in Concrete.

Sir: I note a confirmation of the well established fact that steel embedded in concrete will not rust: In constructing the Rapid Transit subway in lower Broadway, New York City, the Degnon Contracting Co. has found it necessary to tear up the sidewalk around the Bowling Green Park. This walk was laid in 1883 by Matt. Taylor. There are embedded in the slab a number of steel rods which in tearing up the walk have been exposed. These rods are in perfect condition to-day.

Very truly yours, Ernest L. Ransome.

11 Broadway, New York City, April 12, 1904.

Publishing Details of Engineering Construction.

Sir: I was much interested in your article on "Dearth of Writers on Details of Engineering Construction," and feel that I must write you a line to say how very much I agree with what you say. On this side I am afraid that many editors of our technical papers do not properly appreciate technical detail. Some papers consistently refuse line drawings, they will only accept photos.

As you mention formers of concrete in your article, I am sending you a description of the apparatus which Messrs. W. Griffiths & Co. are using to form the concrete trench in the London County Council Tramways.

Yours faithfully, E. Kilburn Scott.

13 St. Helen's Place, London, E. C.

(The conduit former referred to by our correspondent is shown in our article on "A Conduit Electric Railway in London," on another page of this issue.—Ed.)

Specifications for Clearing Right of Way.

Sir: In regard to specifications for clearing right of way by Prof. W. D. Taylor in the issue of Engineering News for April 7, it seems to the writer that this specification is open to serious objection for several reasons. In the first place, the "densest" and "heaviest" clearing is not necessarily the "most expensive." The writer knows of a number of cases where enough "heavy" timber has been sold by the contractors to pay for the expense of clearing, and other cases where the "dense" timber has been cleared for cord wood and all brush and trimmings burned by outside parties with no expense to the contractors. Small brush and thickets, however, are often so overgrown and interlaced with "greenbriars" or "catbriars" that their removal is quite difficult and expensive, with no possible sale of any of the material to balance the account, so that from the contractor's point of view the latter class may be far the most expensive.

The most serious objection, however, is that it leaves the engineer to determine the comparative cost of the different classes of clearing, at some time *after* the letting of the contract, which, without access to the contractors' books, he cannot properly do. It would seem better to tabulate, at the time of location, the general character of the clearing by stations; this to be verified by the contractors on the ground; and invite bids in a "lump sum" for the clearing of the entire line or per mile of line.

The writer believes that all such phrases as, "in the judgment of the engineer," should be eliminated from all specifications, and definite requirements substituted therefor. While the engineer may consider his "judgment" good, the contractors may have facts and figures in their possession which, if they cared to divulge, might prove it was not. E. G. Haines, Assoc. M. Am. Soc. C. E.

5 Hanson Place, Brooklyn, N. Y., April 11, 1904.

The Cost of Concrete Blocks for Manholes.

Sir: I have read with considerable interest the article by Mr. Hugh C. Baker, Engineer of Subway Construction for New York Telephone Co., in your issue of Jan. 21, 1904, on the "Use of Concrete Blocks in Manhole Construction." Referring to the advantages of a manhole built in this way, Mr. Baker says: "The cost is less than the cost of brick manholes of similar size and shape." He also gives a comparative statement of the two kinds of manhole in question, showing a difference in cost of $1.11 in favor of the concrete manhole, but the cost of making molds and of freight is left out. If these blocks were made in large quantities at some distance from the site of the work the item of freight should be added, as the blocks for one manhole weigh more than five tons. The item of "cost of making molds" should be added, or rather a percentage of initial cost of plant and tools, such as molds, concrete mixer, etc. These items would in all probability more than offset the difference of $1.11.

The writer believes that the cost of labor for a brick manhole can be cut to 30 man-hours, as only three men are necessary, one to carry brick, one to hand brick to mason, and one to mix cement. These three men and the mason ought to be able to set the concrete top, as well as build the manhole, in ten hours. We do not know whether superintendence is included or not in the "cost of concrete blocks in place." It should be allowed, however, as no contractor would expect laborers to put together a manhole of this kind, no matter how simple of construction, without some kind of supervision.

It is also claimed that this concrete manhole "can be taken down and used over again with practically no waste of material, if concrete is made properly." If the joints are to be cemented, as undoubtedly they should be to make the manhole waterproof, how can the blocks be taken out without becoming chipped or cracked? Also, how "can the manhole be put together in freezing weather" if there is to be cement in the joints? Furthermore, it is not an easy matter to cut out concrete that has thoroughly set, for the duct entrances.

The manhole, however, has a great many advantages, and the criticisms above-mentioned are merely those that would be in the mind of any one familiar with this class of work. Yours very truly,

W. G. Federlein.

221 E. 116th St., New York, April 2, 1904.

Sand Drifts on a Southern Texas Railway.

Sir: The writer has just visited Brownsville, Tex., which is a unique old town situated on the north bank of the Rio Grande, opposite Matamoras, Mex. The writer went in the interest of a company which contemplates the construction of water works and electric lights, and traveled 156 miles by stage from Alice, the nearest point reached by the railroad. One is surprised to find so many substantial brick buildings in a town which has been completely isolated from the rest of the world. The explanation of the rather pretentious brick buildings is that brick have been cheaper than lumber. The writer was told that brick had been bought and laid in walls for $6 or $7 per thousand.

The soil around Brownsville is very fertile, and within the past three years it has, by irrigation, been converted from a drought-cursed, almost barren land into a land "Flowing with milk and honey," and the improvement is just beginning. So far the chief crop is rice, which yields abundantly, being irrigated with water from the Rio Grande.

The St. Louis, Brownsville & Mexico R. R., or the Lott Road, as it is called, is building into Brownsville, and the track is now within 40 miles of the town. On the return trip from Brownsville the writer traveled over this railroad on construction trains. The object of this communication is to call attention to what was, to the writer, a novel experience, and it may interest other members of the engineering profession.

For the first 40 or 50 miles out from Brownsville the soil is black, with just enough sand to be beneficial to crops. Then comes a region of 30 or 40 miles of almost pure white sand, which in places drifts like snow. During the four or five hours elapsing since the last train had passed, this fine white sand, carried by strong winds, had drifted onto the track in places to a depth of at least 18 ins. above the top of the rail. Each train which passes has to stop at two or three points until the track can be cleared of sand. The writer did not have the pleasure of meeting Mr. F. G. Jonah, Chief Engineer of the road, and doesn't know what plans he may have for overcoming the difficulty, but it is certainly not an easy problem. On some western road, probably the Southern Pacific, the writer understands that snow fences are employed to keep off the sand, but it would seem that the sand would soon drift over the tops of these. On some of the Russian railroads near the Caspian Sea the sand is saturated with salt water, which forms a crust on top, and stops the drift for a while. Crude as it might accomplish something toward overcoming the difficulty, though it might prove expensive.

Perhaps some of the readers of the Engineering News can suggest an effective and economical means of preventing this drifting of sand. Yours truly,

Ruston, La., April 5, 1904.

(The railway connecting Cairo with Ismailia, on the Suez Canal, traverses a similar region of dry, fine sand. To protect the track, snow fences, made of metallic railway ties, seem to be effective. The only permanent relief, however, must be brought about through covering the sandy plain with a forest growth, in a manner similar to the reclamation of the sand dunes of Southern France.—Ed.)

The Corps of Engineers of the U. S. Army, and River and Harbor Works.

Sir: The writer thinks that several statements made by Captain Sewell in his letter in your issue of April 7 concerning the control by the Corps of Engineers of civil engineering works might be considered from another point of view. "It is fitting," he says, "that the improvement and military defense of our navigable channels should be in the same hands." While this control might be advisable for harbors on the seaboard, open to an attack of an hostile fleet, it is hard to see the force of this statement when it is made to justify the assignment to corps of engineers of the regulation and canalization of small streams in the interior of the country, and the improvement of harbors on the Great Lakes. The writer maintains that this work can be done better and more economically by civilian engineers who have specialized along these lines. It seems poor economy to place young military engineer graduates, with no practical experience, in charge of important civil works, because of the lack of experienced officers. It is obvious that their practical knowledge of construction can only be obtained at an additional cost to the Government.

The writer knows of several cases of engineer officers who showed a lack of military engineering training during the campaign in the Philippine Islands, no doubt due to the fact that since their graduation they had been engaged chiefly upon civil engineering work. The engineering corps in the European armies are assigned to military work exclusively, and the writer has yet to learn of their plea for civil work in order "to keep the corps fully occupied in time of peace." If, as Captain Sewell states, the transferring of the public works to civil control will not keep the Engineer Corps sufficiently employed during times of peace, then the argument for a decrease might be advanced as strongly as for an increase in the Corps.

The armies of the United States in time of war are composed of volunteers, and there is no reason for doubting that the volunteer engineer officer serving under experienced officers of the Engineer Corps, would meet with the requirements of modern warfare as successfully as the volunteers in the other branches of the service. The history of the Civil War and of the late Spanish-American war will substantiate this statement.

At the present time many officers of the Engineer Corps are filling positions entirely out of the field of military engineering, such as the direction of municipal engineering work of the District of Columbia, the charge of the Washington Aqueduct and filtration plant, the care of the National Parks, the superintendence of the construction of public buildings, and other works.

The Engineer Corps has always been held in high esteem by those who are familiar with its past and present achievements, and it is not the writer's desire to criticise the capability of the Corps for performing the multitudinous duties assigned to it, but rather the system that taxes its resources to direct the vast engineering projects of the Government, in lieu of assigning this work to civilian engineers, who are specialists along these several lines; thus allowing the Corps to devote its energies to works of a purely military character.

Very respectfully, Francis R. Weller, C. E.

1416 F St., Washington, D. C., April 9, 1904.

Some Former Experiences with Lighthouse Construction on Diamond Shoals.

Sir: In Engineering News of April 7 the writer noted with pleasure mingled with some anxiety "A new plan for a lighthouse on Diamond Shoal."

Some years ago he decided to devise a method of building a substantial structure upon that shoal. His experience was in line with the undertaking. For centuries the engineer has executed unique work and accomplished it by adopting unprecedented methods. A Venetian engineer did so, when he transported a fleet of warships 50 miles overland, passing on the way an obstruction 300 ft. in height. The transportation of a monolith weighing 5,000 tons, many hundreds of miles, had been accomplished as many years before. A sea wall is in existence—and perfect—in the vicinity of the first—and only walled—

city built on the continent of America. An Algerian engineer built another sea wall hundreds of years before the former was thought of. This also stands to-day, though the largest stone in the structure was carried on the head of a slave. The same engineers raised sunken—not beached—ships successfully and frequently. In those days ships were not big row-boats, as many suppose, there were plenty of ships then, capable of carrying "six hundred souls" and were ballasted with "a cargo of wheat." Ships were transported across the Isthmus of Corinth long before an illustrious engineer thought of doing the same thing across Tehuantepec.

In prosecuting an investigation of the nature intimated, valuable information is obtained from unexpected sources and unsuspected places. From the splendid work of Lieut. Maury, in his "Physical Geography of the Sea," valuable suggestions were obtained. About the year 1880, while perusing a report issued by a British authority on maritime disasters, the writer read that a ship known to have been wrecked nearly a century ago, was literally upheaved from the shoals of Goodwin Sands, and about the same time a vessel had a similar experience in the neighborhood of Hatteras. The writer immediately set about ascertaining the cause of these strange expulsions. The investigations were pursued from Capt St. Roque, to the east coast of Florida, to Hatteras, to Sable Island and to the Goodwins. In all these places the writer saw floats made of wood, empty but tight casks and similar buoyant articles frequently become engulfed beneath the sands, in from one to six tides.

Some time in 1890 bids for building a lighthouse on Diamond Shoal were requested through the columns of Engineering News. The writer communicated with several of the bidders for that work, and explained to them his reasons why it would be necessary to adopt unique methods in handling a caisson off Hatteras. Including the (un) successful one, the bidders were told: "You will never found a caisson on Diamond Shoal if you follow the methods usually employed in sinking one in quiet water." Subsequent events proved that the writer's deductions were well grounded. In the autumn of that year an advertisement appeared in the Engineering News. As near as can be remembered, it was something like this:

Lost.—On or about Diamond Shoal, one caisson. The finder will be rewarded upon giving such information as will lead to its recovery. Signed J. B.

The advertisement was characteristic of its author, he took his medicine like a man. Needless to say the reward was never claimed. If the new bell-shaped metal caisson is to be navigated, I feel sure my old friend will succeed, but if it is to be built upon and prevented from sinking out of sight, a web-footed civil engineer would be more at home with that job. At least that is the conclusion arrived at after much study by: The Captain.

36 Emerald St., Hamilton, Ont., April 13, 1904.

Methods of Overhaul Computation Compared.

Sir: In discussing "overhaul" in the Construction News Supplement of your issue of March 17, you say "the common method" (i. e., the maximum free haul method) "is certainly the more logical," and again "the contractor is not concerned so much with what the average haul is, as what the actual haul is." Is it not a fact that the average haul method more nearly represents the actual overhaul than does the extreme or maximum haul method?

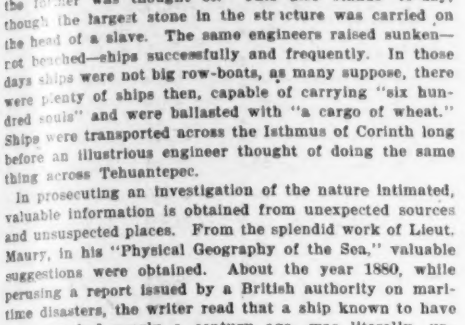


Fig. 1.

A surface profile of a cut and fill corresponding to the quantity profile, Fig. 1 (reproduced from page 189) would be of the form of Fig. 2.

The maximum haul method of computing overhaul is based on the assumption that the cut is taken out to grade and that the fill is built up to grade as the work progresses each way from the grade point. This is sometimes done, but specifications generally require that the embankment shall be built up in layers from the bottom, and when cars or wheel scrapers are used material is removed from the whole surface of the cut long before any part of it has been brought to grade, so that the layers similarly shaded in Fig. 2, show approximately the place in the fill occupied by material from the cut.

It seems to the writer that in such a case the actual haul would be more nearly determined by the average haul method than by the other, and with a clause in the specifications no more definite than the one quoted, the engineer might be justified in using that method of computation.

As to comparative results by the two methods applied to the cut and fill shown by these figures: You apply the average haul method by first determining the center of gravity of cut and of fill and obtain 21,233 cu. yds. overhaul. To obtain the overhaul by the maximum haul method, would it not be more logical to find the centers of gravity of remaining portions of cut and fill after the free haul limits are determined and proceed thus:

Centers of gravity are at stations 1 + 77.3 and 12 + 22.7

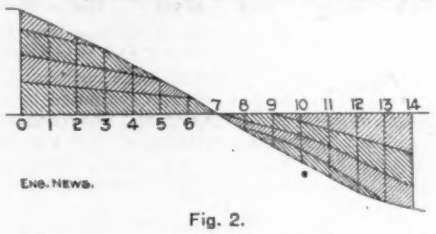


Fig. 2.

or 1045.4 ft. apart; taking out the free haul limit and the amount of material within this limit (623 yds.) we have 4,275 cu. yds. overhauled 545.4 ft., or 22,316 cu. yds. overhauled 100 ft., which is 1,083 cu. yds. in excess of the amount determined by the average haul method. A simple and satisfactory method frequently used by the writer for finding the center of gravity of a cut or fill or a portion thereof is to cut out with a knife or scissors the quantity profile and balance same on a knife blade.

Very truly yours,

H. H. Wadsworth, M. Am. Soc. C. E.

Superior, Wis., March 19, 1904.

[Replying first to the question as to the relative reasonableness of the two methods of overhaul, we concede that where the contractor is required to build the embankment in layers, as illustrated in Fig. 2, there is good reason for maintaining that the average haul method is more "logical." But the fact is that we rarely see a railroad embankment built in that way, in spite of the fact that specifications often call for construction of embankments in horizontal layers.

Relative to our correspondent's second question, it may be answered that to be precisely accurate the center of gravity of the truncated pyramids (Fig. 1) should be determined. But in practice to find the centers of gravity with exactitude is not worth the trouble involved. Our correspondent finds by the precise method that the overhaul is 22,316 cu. yds. overhauled 100 ft., whereas, by the method given in our issue of March 17, we found the overhaul to be 22,137 cu. yds. overhauled 100 ft.—a difference of only 179 cu. yds. overhauled 100 ft. However, we had not intended to convey the impression that the multiplication method of computation is to be used in common practice at all. Indeed, it is much more satisfactory to use a graphic method, such as given in Gillette's "Earthwork and Its Cost," plotting the yardage between stations on profile paper, excavations being considered plus and embankments minus.—Ed.]

Notes and Queries.

Mr. Chas. A. Budd, formerly of Indianapolis, Ind., is requested to send his present address to the office of Engineering News.

In connection with the shocking accident at the dam at Boonton, N. J., last week, where a diver lost his life in attempting to close a large outlet pipe whose gate-valve had stuck, we are requested by the Coffin Valve Co., of Boston, Mass., to give place to the following statement:

Owing to the many inquiries which we have received concerning the accident at the Boonton dam, we wish to state for the information of our friends that the gate-valve referred to was not of our make, our installation having been confined entirely to the sluice valves.

METHOD OF COMPUTING DAILY AND MONTHLY DISCHARGE OF STREAMS WITH SANDY, CHANGEABLE BED.

By E. C. Murphy,* Assoc. M. Am. Soc. C. E.

The discharge of a stream at a given place is the product of the cross-section and mean velocity. The mean velocity is a function of the surface slope, wetted perimeter, cross-section and roughness of the bed. If these quantities remain constant the discharge will remain constant, and whenever the stream returns to a given stage or gage height, say 5 ft., the discharge will be the same as found at any other time for this gage height. The latter part of this statement is not strictly true because the surface slope is somewhat greater for a given stage when the stream is rising than when it is falling, especially when the change is rapid. This assumption of a fixed relation between stage and discharge of a stream of permanent bed is the basis of the common method of computing daily and monthly discharge.

*Engineer, Hydrographic Branch, U. S. Geological Survey, Washington, D. C.

In the common method of computing daily and monthly run-off the discharge and corresponding gage height are obtained at the station for each foot or less of stage. These points are plotted on squared paper using gage heights as ordinates and discharges as abscissæ and a smooth curve called the station rating curve drawn among them so as to have about as many points on one side of it as on the other. Fig. 1 shows a station rating curve for the U. S. Geological Survey gaging station near Yuma, Ariz., prepared from the data in Table I. Table II. is prepared from the rating curve in Fig. 1. Discharges can be obtained more accurately and quickly from it than from the curve. The gage height for a day is obtained from one or more readings of the gage taken during the day or from the sheet of a water register. The mean discharge for the day is the discharge for the mean daily gage height. The mean

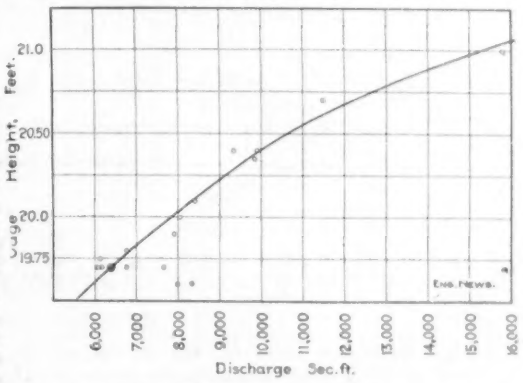


Fig. 1. Station Rating Curve for the U. S. Geological Survey Gaging Station at Yuma, Ariz.

(Prepared from the data given in Table I.)

monthly discharge is the sum of the mean daily discharge divided by the number of days in the month.

If the stream at the station has a sandy changeable bed the above method is not applicable because the gage height is not an index of the discharge for any considerable length of time. Two methods of computing daily discharge have been devised by hydrographers of the U. S. Geological Survey for such conditions. One of these, which we will call the correction curve method, was proposed by Prof. O. V. P. Stout of the University of Nebraska. In this method a mean station rating curve is used and the mean daily gage

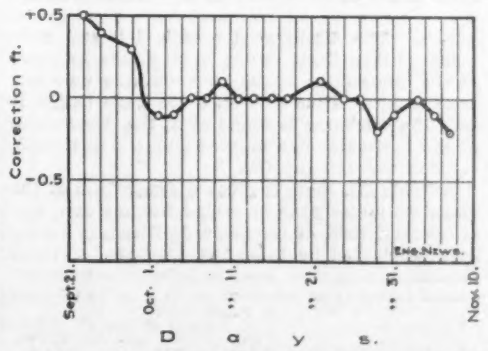


Fig. 2. Daily Gage Height Correction Curve for the Month of October for the Yuma Gaging Station.

heights are corrected by amounts given by a daily gage height correction curve.

The discharge is measured weekly and in some cases two or three times per week and compared with that shown by the station rating curve. The difference between the observed gage height and that given by the station rating curve for this discharge is the correction to the gage height. The correction is positive if the discharge is greater than that given by the station rating curve, negative if the opposite. These gage height corrections are plotted using the correction to the gage

as ordinates and days of the month as abscissæ and the points connected by a smooth curve. The daily gage height correction due to the change in bed is then taken from this correction curve and the corrected gage height written in its proper place with red ink. The mean daily discharge is then taken from the station rating curve using the corrected gage heights. The daily gage

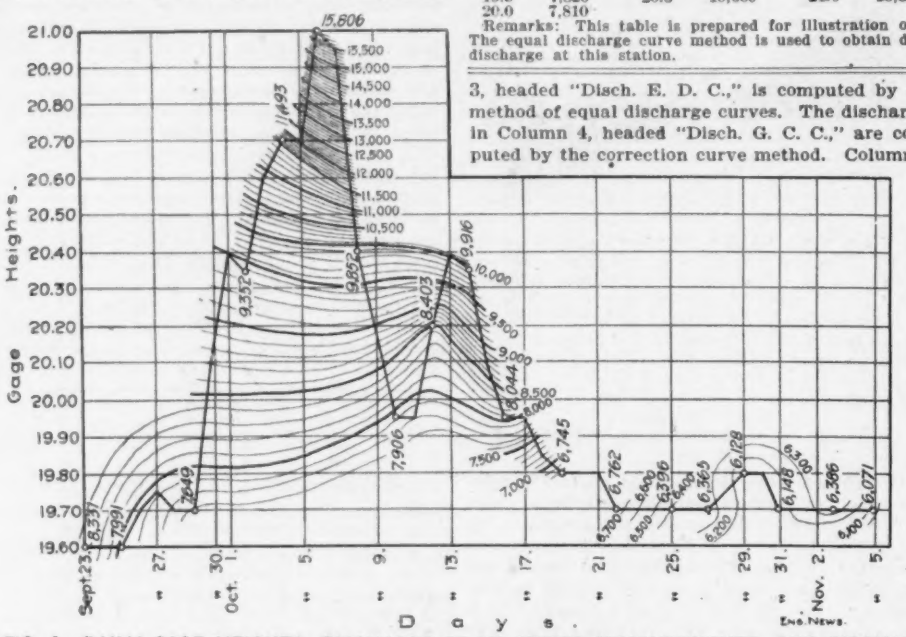


FIG. 3. DAILY GAGE HEIGHTS, DISCHARGE FROM METER MEASUREMENTS, AND DISCHARGE CURVES BASED ON CONTOUR INTERVALS AT THE YUMA GAGING STATION, OCTOBER, 1903.

(Discharge in cubic feet per second.)

height correction curve for the station on the Colorado River, at Yuma, Ariz., for the month of October is shown by Fig. 2.

The second method, which we will call the equal discharge curve method, was proposed by Mr. W. B. Clapp, Yuma, Ariz. In place of a station rating curve, curves of equal discharge similar to contour curves (curves of equal elevation) are drawn from the discharge measurements, and the daily discharge obtained from these. These curves for the station at Yuma, Ariz., on the Colorado River for the month of October, 1903, drawn from the data in Table I., are shown by Fig. 3.

The discharge measurements are plotted as shown, using gage heights as ordinates and time as abscissæ and the discharge written near each plotted point. These points are then connected by lines and curves of equal discharge drawn among these points in the same way as contour lines are drawn when the elevations of certain points are known. The discharge for each day and gage height is then found on the equal discharge curve at the intersection of the lines marking time and gage height. Thus on Oct. 5 the gage height is 20.7, the discharge is found at a, the intersection of the horizontal line marked 20.7 and the vertical line through the Oct. 5.

In Table III. there is given a comparison of the mean daily discharge in second-feet for each day of October, 1903, of the Colorado River, at Yuma, Ariz., computed by these two methods. Column

TABLE I.—Discharge Measurements Made on the Colorado River, at Yuma, Ariz.

Date. 1903.	Hydrographer.	Gage height, ft.	Area of section, sq.ft.	Mean velocity, ft. per sec.	Discharge, cu.ft. per sec.
Sept. 23.	W. D. Smith..	19.60	1,748	4.77	8,331
" 25.	" " ..	19.60	1,745	4.58	7,991
" 29.	" " ..	19.70	1,714	4.46	7,649
Oct. 2.	" " ..	20.40	2,057	4.55	9,352
" 4.	" " ..	20.70	2,558	4.49	11,493
" 6.	" " ..	21.00	2,800	5.53	15,806
" 8.	" " ..	20.35	2,234	4.41	9,852
" 10.	" " ..	19.90	2,358	3.35	7,906
" 12.	" " ..	20.10	2,350	3.56	8,403
" 14.	" " ..	20.40	2,453	4.04	9,916
" 16.	" " ..	20.00	2,386	3.37	8,044
" 19.	" " ..	19.80	2,506	2.69	6,745
" 22.	" " ..	19.70	2,533	2.67	6,763
" 25.	" " ..	19.70	2,442	2.62	6,396
" 27.	" " ..	19.70	2,475	2.57	6,365
" 29.	" " ..	19.75	2,357	2.60	6,128
" 31.	" " ..	19.70	2,165	2.84	6,148
Nov. 3.	" " ..	19.70	2,307	2.77	6,386
" 5.	" " ..	19.70	2,322	2.61	6,071

TABLE II.—Rating Table for the Colorado River, at Yuma, Ariz.

(This table is applicable only from Oct. 1, 1903, to Oct. 31, 1903.)

Gage height, ft.	Discharge, sec.-ft.	Gage height, ft.	Discharge, sec.-ft.	Gage height, ft.	Discharge, sec.-ft.
19.5	5,500	20.1	8,320	20.6	11,380
19.6	5,940	20.2	8,850	20.7	12,190
19.7	6,390	20.3	9,410	20.8	13,110
19.8	6,850	20.4	10,010	20.9	14,150
19.9	7,320	20.5	10,660	21.0	15,320
20.0	7,810				

Remarks: This table is prepared for illustration only. The equal discharge curve method is used to obtain daily discharge at this station.

3, headed "Disch. E. D. C.," is computed by the method of equal discharge curves. The discharges in Column 4, headed "Disch. G. C. C.," are computed by the correction curve method. Column 5, headed "Disch. S. R. C.," gives discharges taken from the station rating curve, Fig. 1.

It is seen that although the corresponding discharges for any day, computed by these methods, differ by considerable amounts in some cases, the mean monthly discharges differ very little, the greatest difference being about 1.3% of the larger.

For a greater monthly range of gage heights the monthly differences in discharge would probably be greater than shown by Table III.

The method of equal discharge curves requires more time for its use than the correction curve method and the accuracy gained by it will scarcely justify this increased labor if the gage is only read to tenths of a foot. If a self-recording water gage is used so that gage heights can be scaled from a sheet the equal discharge curve method will probably give better results than the correction curve method. The mean monthly discharge obtained from the station rating curve is seen to agree closely with that by either of the special methods. If, however, a station rating curve for the year had been used instead of that for October the difference between the results by the special methods and the common method of station rating curve would be much greater.

TABLE III.—Comparison of Daily Discharge of the Colorado River, Yuma, Ariz., for the Month of October, 1903, as Computed by Three Methods: by Equal Discharge Curves, Gage Corrections Curve, and Monthly Station Rating Curve.

Date.		Gage, ft.	Discharge. E. D. C.	G. C. C.	S. R. C.
Oct.	1	20.4	9,500	9,410	10,010
"	2	20.4	9,352	9,410	10,010
"	3	20.6	10,825	10,660	11,380
"	4	20.7	11,493	11,380	12,190
"	5	20.7	11,950	11,380	12,190
"	6	21.0	15,806	15,320	15,320
"	7	20.9	15,500	14,150	14,150
"	8	20.0	9,852	7,810	7,810
"	9	20.2	8,750	9,410	8,850
"	10	20.0	7,906	8,320	7,810
"	11	19.9	7,800	7,810	7,320
"	12	20.2	8,403	8,850	8,850
"	13	20.4	10,100	10,010	10,010
"	14	20.3	9,916	9,410	9,410
"	15	20.2	8,700	8,850	8,850
"	16	20.0	8,044	7,810	7,810
"	17	19.9	7,925	7,320	7,320
"	18	19.9	7,200	7,320	7,320
"	19	19.8	6,745	6,850	6,850
"	20	19.8	6,750	7,320	6,850
"	21	19.8	6,755	6,850	6,850
"	22	19.7	6,762	6,850	6,390
"	23	19.7	6,625	6,850	6,390
"	24	19.7	6,500	6,390	6,390
"	25	19.7	6,396	6,390	6,390
"	26	19.7	6,380	6,390	6,390
"	27	19.7	6,365	6,390	6,390
"	28	19.7	6,250	6,390	6,390
"	29	19.8	6,128	6,390	6,850
"	30	19.8	6,140	5,940	6,850
"	31	19.7	6,148	5,940	6,390
	Sum		262,966	259,570	261,980
Mean			8,483	8,373	8,451
				1.3%	

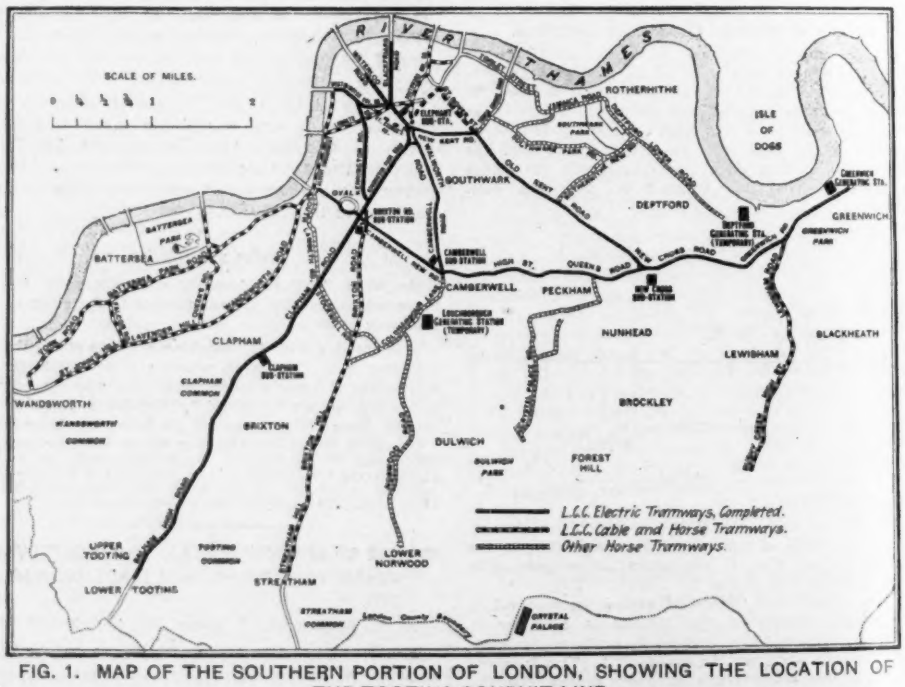


FIG. 1. MAP OF THE SOUTHERN PORTION OF LONDON, SHOWING THE LOCATION OF THE TOOTING CONDUIT LINE.

A CONDUIT ELECTRIC RAILWAY IN LONDON, ENGLAND.

The first electric street railway of the conduit or "underground trolley" type in the city of London, England, is now in operation, a section of about 8 miles having been opened for traffic in May, 1903, while the second half, about 10 miles long, was opened only in January, 1904. There is only one other line of this type now operating in England; two others which were built some years ago have been abandoned or converted into overhead trolley lines. There are only about half a dozen conduit electric street railways in the world, notable among them being the street railway systems of New York and Washington.

The London line, built and operated by the London County Council, possesses a special interest because it forms the first part of a development which is to give London some degree of modern surface transportation, at least in the district lying south of the Thames. The first half of the line runs from the outlying district of Tooting, in South London, to the Thames River, branching to Westminster, Waterloo and Blackfriars bridges, and has a total length of 8.2 miles double track. The more recently opened portion connects with the Tooting line at the Elephant-and-Castle, and runs thence easterly to Greenwich; a branch runs from Vauxhall bridge through Camberwell to a junction with the Greenwich line at New Cross, and a north and south branch connects Camberwell with the Elephant-and-Castle. This second portion aggregates 19 miles of single track, or, since practically all of it is double-track, the line is 9.5 miles in length. Thus the total length of the London conduit lines constructed up to the present is about 18 miles. A considerable amount of additional line is planned, but most of this will be equipped with overhead trolley instead of conduit.

The London County Council conduit lines are the direct outcome of an investigation of the subject of mechanical traction for tramways which was undertaken for the Council in 1899 by Mr. A. B. W. Kennedy, with the object of determining what system of traction, other than steam or cable, was to be preferred for London conditions. The report favored the conduit electric system and advised that as an experiment a small part of the proposed network be constructed of this type before final action was taken on the remainder. Plans for the work were prepared in 1901 by Mr. J. H. Rider, who had been appointed electrical engineer for the Council, and the contract was awarded to J. G. White & Co. on these plans with modifications suggested by them.

The accompanying map, Fig. 1, reproduced from "The Electrician" (London), shows the location of the completed lines relative to the portion of London lying south of the Thames. It was originally proposed to build a central power station in the Camberwell district, to serve the whole of the proposed system. While this is a central location it is inconvenient for the supply of coal and condensing water. It was finally decided to locate the station at Greenwich, directly on the river, and to distribute by high-tension polyphase alternating current to a number of substations (Clapham, Brixton Road, New Cross, Camberwell, Elephant, and Streatham), where it will be converted to 550-volt direct-current for supply to the conductor-rails. The main station and substations are now being built. Current for operating the line is being supplied at present by temporary plants, placed one in the Deptford station of the London Electric Supply Corporation, the other in the Loughborough station of the South London Electric Supply Co.

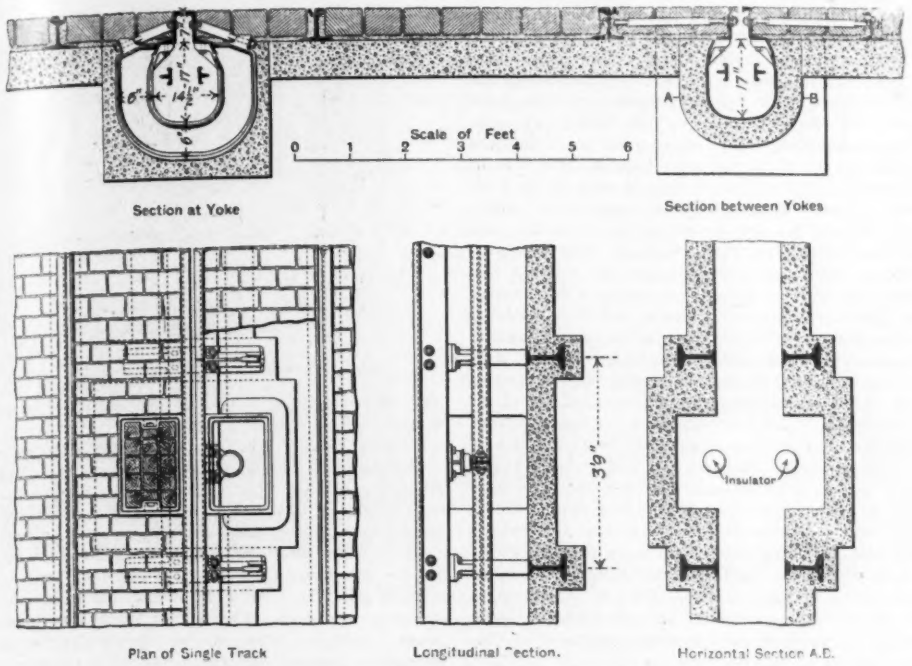


FIG. 2. PLAN AND SECTIONS OF TRACK, SHOWING STANDARD LINE CONSTRUCTION.

TRACK AND LINE.—The track is of standard gage, 4 ft. 8½ ins. The conduit is in the middle, between the rails (center-slot arrangement); it differs, however, from the usual design of this type of conduit in that the cast-iron yokes which form the skeleton of the conduit are not extended to form supports for the track-rails, but these latter rest independently on an 8-in. concrete bed forming the foundation of the track. The actual construction is clearly shown in Fig. 2. The cast-iron U-shaped yokes are spaced 3 ft. 9 ins. on centers (lengthways of the track), and the two Z-shaped rails which form the slot rest on the upper surfaces of the yokes and are braced to them by short tie-bars. Similar tie-bars at intervals extend from the yokes to the track-rails, and between alternate pairs of yokes the track-rail on either side is tied to the corresponding slot-rail by other tie-bars. The conductor-rails are hung from insulators whose supports are fastened to the lower flange of the slot-rail. The entire track rests on a concrete bed, which joins with the concrete walls of the conduit.

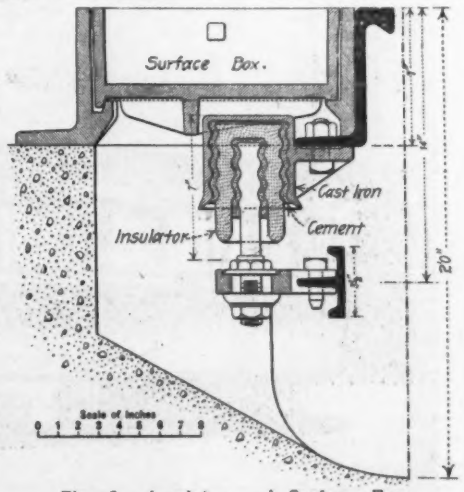


Fig. 3. Insulator and Surface Box.

It should be noted that where the line crosses bridges a shallower conduit had to be used than that shown in Fig. 2. These shallow portions are cleaned daily, to avoid accumulation of mud. On a short piece of line in Greenwich, only single track could be laid. Here the two conduits are kept separate, side by side, double yokes being employed. The two sets of insulator supports are staggered.

The track-rails or running-rails are grooved girder rails 7 ins. high, weighing 102 lbs. per yard; the groove is 1 1-16 ins. wide on tangent, and 1 3-16 ins. on curves. The earlier joints were made by fish-plates of a special pattern to receive which the ends of the track-rails were milled for a length of 10 ins. and a depth of ¾-in. by a special machine. Later, when this type of joint, the so-called Dick-Kerr joint, was found not fully satisfactory, ordinary six-bolt fish-plate joints were used, reinforced by a base-support formed by a piece of inverted rail bolted under the flange of the track-rail. The slot-rails, which weigh 62½ lbs. per yard, are 7 ins. high and 2 ins. wide on top; the slot between them is ¾-in. wide. The top of the slot-rails is ½-in. above the top of the track-rails. The T-shaped conductor-rails are made of a special steel having high electrical conductivity; with a face width of 3½ ins. they weigh each 22 lbs. per yard. Flexible copper bonds with solid plug ends are used for connecting the consecutive (30-ft.) lengths of conductor-rail. The track-rails do not require to be bonded, as they carry no currents; they are first laid in 30-ft. lengths, but later 45-ft. rails were used in order to diminish the number of the joints.

The support of the conductor-rails is made clear by Fig. 3, a half section of the conduit at an insulator. A horizontal forked arm gripping the stem of the conductor-rail is held between two nuts on a vertical iron pin. This pin is set with Portland cement in an inverted cup-shaped insulator, and this is similarly held in a cup-shaped casting which is bolted by a flange to the lower surface of the slot-rail. Means for adjusting the conductor-rail transversely, so as to bring it into proper alinement, are provided as follows: The upper nut on the iron pin is not screwed on the pin, but rests against a collar. Its upper portion is hexagonal so that it may be turned by a wrench; its lower portion forms an eccentric cam, which works in a transverse slot in the arm supporting the conductor-rail. Thus, after loosening the lower or clamping nut, the arm and rail may be shifted inward or outward a slight amount by turning the upper nut, or rather cam, and the arm then secured in position by tightening the lower nut.

The insulators are spaced 15 ft. apart, so that there is one insulator in the middle of each length of conductor-rail, and one at each joint. The conduit is widened out at the insulators, as is shown clearly in Fig. 2. A cast-iron surface box in the pavement gives access to the insulator; it rests partly on the slot-rail and partly on the concrete wall of the conduit.

The conduit itself is formed of concrete, with 6-in. walls; the inside is coated with cement plaster. At the upper and inner edges the concrete is strengthened by steel plates resting between the yokes. In building the conduit, after the yokes were put in place, collapsible forms were set inside, spanning from yoke to yoke, and the concrete was then tamped around the forms. After the concrete had started to set, the forms were drawn together, and pulled along the inside of the finished conduit to another section. Fig. 4 shows two styles of form that were used for this work. The wooden form shown at A is spread by the central bar bearing against inclined faces of the halves of the cross-frames. To move the form this bar was raised and withdrawn, whereupon the two halves of the form could be drawn to-

gether and moved past the yoke to the next section. A better style* of form, the invention of Mr. J. E. Hall, is shown at B, Fig. 4. Here the form is composed of two bent plates of sheet-iron, hinged together at the bottom, and connected by toggle-arms having handles projecting up through

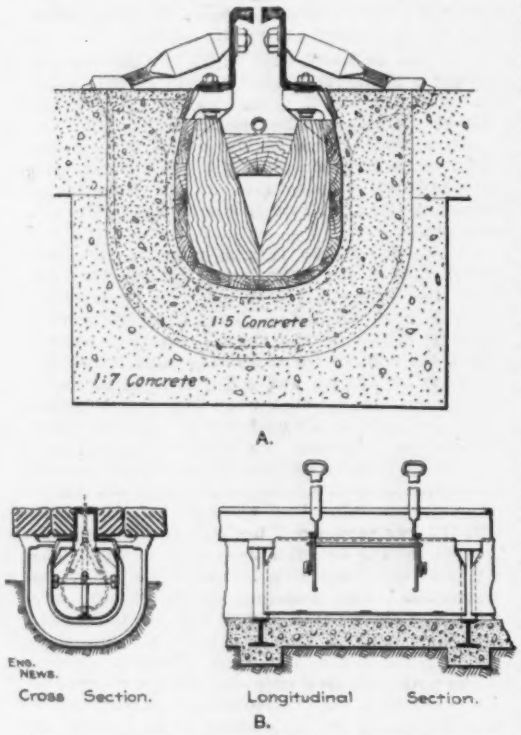


Fig. 4. Wooden Form Used in Concreting the Conduit.

the slot. By pulling up on these handles the form is drawn together, as shown by the dotted lines in the cut, and it can then be slipped along past the projecting lugs of the yoke to the next section. When the sides are spread out, the foot of the handle-bar bears against the bottom of the form and thereby limits the motion.

The insulators and conductor-rails are put in place after the entire trackwork is completed. Placing and adjusting the insulators is easily done through the surface boxes, and the conductor-rails are drawn in, from a section left open for this purpose, by hooks passed through the slot. The bonds of the conductor-rails are fastened by a hydraulic press of special design which can work through the opening of the surface-box.

At intervals of about 100 to 125 ft. the conduit is drained by a 12-in. pipe into a cleansing or settling pit, which is trapped to the sewer. These pits were at first placed to one side of the track, but this was found to result in imperfect drainage of the conduit lying nearer to the pit, so that the pits on the second part of the work were placed between the tracks.

A special arrangement of the conductor-rails is used in the car-sheds, where the space between the track-rails is excavated to form working pits. As a central arrangement of the conductors is impracticable here, they are shifted to the side, as shown in Fig. 5 (the plow on the car is supported on transverse slides, so that it readily follows the slot). A wooden shield around the conductors prevents danger from accidental contact; the top of this shield is hinged for access to the conductors and insulators.

Electrically, the conductor-rails are divided into sections about half a mile long, the break being about 2 ft. (at switches and crossings the break is, of course, longer). To the junction of every two sections is led a feeder from the nearest substation. The feeder terminates on a small slate switchboard enclosed in a cast-iron housing, which is set up on the curb line at the junction point. The eight leads from the conductor-rails (two rails for each of the two tracks, for both adjoining sections), are also brought, underground, to this switchboard. The terminals of the eight track leads and the two feeder terminals are all separate, and may be connected by means of bars or "connection links" provided for that purpose. The connection may be made in various ways; thus, both adjoining sections of track may be fed at that switchboard or "feeder-pillar," or only one of the sections may be supplied there, leaving the other to be fed from the feeder-pillar at its other end, or the two sections may be connected across the junction, leaving the feeder dead-ended (as in case the feeder is out of service), etc. The feeder-pillar has a door on either side, with different keys, and the switchboard is mounted in the middle, one side facing either door. The link-connections as above are made on one side, to the door of which the station attendants alone have keys. On the other side of the board are eight cut-out switches, one in each track lead, and the motormen are provided with keys to this side of the pillar. The object of this is that if an accident or block occurs on either track of an adjacent section, the motorman can cut off the current at the nearest feeder-pillar. The link-connections are necessary because the feeders are connected at the substation in such a manner that their polarity may be reversed when desired. The negative side of each feeder is earthed at the substation switchboard. Should the positive side develop a fault, it may be made the negative (with earth connection) so that the fault is of no consequence. The reversal of a feeder requires, of course, that its connections to the track leads be appropriately changed, as otherwise there might be a short-circuit between two feeders through one section of track. The double-sided arrangement of the feeder-pillars has the object that these connections may be made only by those who also have the feeder connections at the substation under their charge. Fig. 6, which is a view of a feeder-pillar on the switch side, will serve to give an idea of the arrangement of the switchboard.

The electric cables from the substations to the feeder-pillars are single-core; the cross-section of the conducting core varies from 0.10-sq. in. to 0.75-sq. in. The insulation is 0.12-in. minimum thickness, and the lead sheath 0.10 to 0.12-in. thick. It was required that the cable stand a test of bending six times in opposite directions around a drum 2½ ft. in diameter, and a subsequent electrical test of 2,500 volts applied for five minutes. The cable is laid in stoneware duct, 3¼ ins. diameter inside and hexagonal outside. The 18-in. lengths of duct are jointed by being butted together and the joint wrapped with impregnated canvas. The several ducts in the same street are laid close together and the whole set encased in cement.

The main line cables, supplying current from the power house to the substations, will (in the final system with high-tension three-phase distribution) be three-core cables of cross-section either 0.075 or 0.15-sq. in. per conductor, with 0.25-in. insulation between conductor and sheath, and at least 0.20-in. between conductors. The cable is to have a wrapping of copper [illegible] 0.05 to 0.075-sq. in. in total section, over which is the lead sheath, 0.13 to 0.175-in. thick. The copper wrapping has the object of enabling the sheath to carry a heavier current in case of leakage at a fault. These cables are to be tested by bending six times in opposite directions around a [illegible] drum,

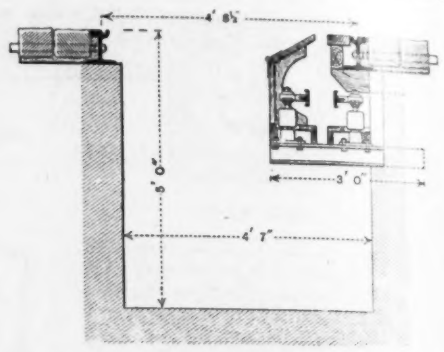


Fig. 5. Track Construction in Car Pits.

and then applying a test voltage of 25,000 volts between conductors for 5 minutes.

CAR CONSTRUCTION AND EQUIPMENT.—The present complement of cars comprises single and double-truck cars, all being double-decked as is customary in England in accordance with omnibus and horse-car practice. One of the two-truck cars is shown in Fig. 7. Its dimensions are 33 ft. 6 ins. long over the buffers and 7 ft. 1 in. wide over all; it has a seating capacity of 66. The trucks are of the "Maximum Traction" type; one of the trucks has an extension inward on which the plow-carrier is supported. The car underframing is of teak, the side sills being reinforced with angle-irons. The body framing is ash, the finish mahogany, white wood and quartered oak.

On the lower floor the seats run along each side, but on the roof they are arranged in two rows of cross-seats. The roof of the car is double-sheathed; it is flat, that is, it carries no monitor, but ventilator sash are fitted in the sides of the car just below the roof.

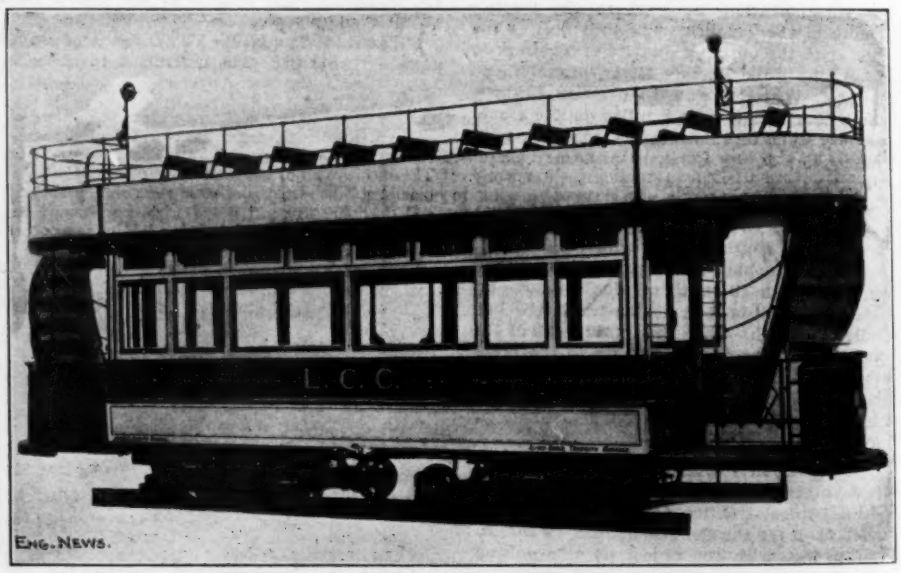


FIG. 7. VIEW OF TWO-TRUCK DOUBLE-DECK CAR.

The cars are equipped with two 37-HP. motors, made by Dick, Kerr & Co., and designed especially for the high acceleration desired on this line. The field frame or shell of the motor is divided horizontally, the bearings for armature shaft and axle being formed in the upper half, so that the lower half may be swung down for inspection or repair. The commutator is reached by a cover over the brushes. The bearings for

*For notice of this style of form we are indebted to Mr. Ernest Kilburn Scott, of London.

the armature shaft are of bronze, while the axle bearings are lined with babbitt in malleable iron shells. The armature shaft carries a pinion which gears to a gear wheel on the car-axle.

The chief feature of the electrical equipment is the provision of brake notches on the controller, by which the motors may be short-circuited so as to act as generators and send current through the resistances for rapidly stopping the

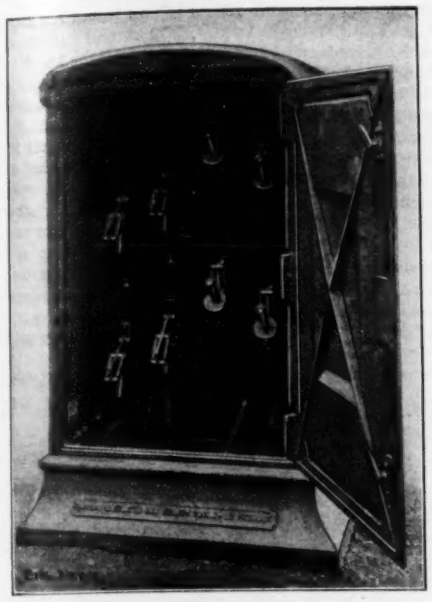


Fig. 6. View of a Section-Pillar from the Switch Side.

car. It is not known whether it is intended to use this electric braking in regular operation, but we presume this to be the case. A handbrake is provided in addition. The circuit breakers and cut-out switches in the main circuit are double, one being located in the canopy at each end of the car; this is necessary because of the metallic return in the conduit system.

POWER HOUSE AND SUBSTATIONS.—The temporary supply of electricity is furnished by a station built by the London County Council alongside the plant of the South London Electric Supply Co., at Loughborough, for the Tooting line, and a generating outfit placed in the Deptford station of the London Electric Supply Corporation, for the Greenwich line. In both cases steam is bought from the company.

The power equipment in both stations is in 1,500-KW. units. The engines are alike for both stations, but the generators in the Loughborough station are 12-pole direct-current dynamos, generating current at 625 volts, while those at Deptford are three-phase alternators giving 25-cycle current at 6,600 volts. This is transformed in the substations to 550-volt direct current by synchronous motor-generator sets, in units of 300 KW.

These motor-generators consist of a 10-pole rotating-field synchronous motor, taking current directly at 6,600 volts, three-phase, and a 6-pole railway dynamo, 550 volts; the set runs at 300 r. p. m. The shaft connecting the two machines of the set has a central bearing, at each side of this bearing is a flange coupling, so that either side may be disconnected independently and the rotor lifted out. The exciter for the set is mounted directly on the common shaft. When any set in a given substation is working, the other sets may be started from the direct-current side, a switch being provided for this purpose. For starting the first set, a 50-KW. motor-generator, driven by induction motor, is provided. The direct-current provided by this machine is sent in parallel through the exciter and the field of the synchronous motor. The exciter then starts up as motor, and the large set is gradually brought up to synchronism. Then the armature of the synchronous motor is switched on to the line so that it drives the set, then the field-strength of the exciter is increased until its current reverses and the exciter takes up its proper function, whereupon the starting set is switched off.

The outgoing feeder switches at the substations are fitted with a set of testing contacts; when any switch is being closed, so as to supply an outgoing feeder, it first makes connection through a resistance and a set of lamps arranged so as to indicate at a glance which side of the outgoing feeder has the lower insulation resistance. This side may then be made negative, the switch being arranged with two sets of contacts so that either side of the feeder may be connected to either busbar.

The permanent power house at Greenwich will contain principally 5,000-KW. units. Each engine will consist of a pair of engines having each a vertical high-pressure cylinder and a horizontal low-pressure cylinder. The two connecting rods of each side work on the same crank-pin. The generator is mounted on the shaft between the two halves. The engines will be 33½ and 66 ins. by 4 ft. stroke, to run at 94 r. p. m. with steam at 180 lbs. per sq. in. and a vacuum of 26 ins. The cranks on the two sides of the engine are set 135° apart.

COST.—The contract price for the track and line work of the Tooting line, except the feeder cables and the rails, was about $840,000. The rails (track, slot and conductor-rails) cost about $252,000. The remaining items in the system are included in the following summary:

Line work and rails	$1,092,000
Cars (100)	353,000
Power house and cables	361,000
Substations	101,000
Car sheds and shops	166,000
Miscellaneous	73,000
Total	$2,146,000

This is at the rate of $262,000 per mile of double track or $131,000 per mile of equivalent single-track road. The actual expenditure will be brought below this figure by the amount which will be realized from the sale of old rails, etc. However, it is to be remembered that the permanent power house has not yet been built.

THE CONTROL OF HUMIDITY BY MEANS OF THE HUMIDOSTAT.

By W. S. Johnson,* M. Am. Soc. M. E.

Very interesting articles and communications have appeared in recent issues of Engineering News, with reference to humidity in dwelling houses. There has been discussion as to its value, and as the ground has been thoroughly gone over, I do not consider it necessary to use any further argument in favor of moistening the air of dwelling houses. The same arguments of course would apply to auditoriums and school buildings. The usefulness of humidity is greatly extended in technical manufactures, humidity being universally used now in textile mills as well as many other kinds of manufacture which I might mention.

The object of this article is to explain briefly a method of controlling humidity. Without control it is of very little value, because when humidity is used without automatic control it is very difficult to keep it within the desired range. All forms of stationary hygrometers are notoriously inaccurate. The only form which is accurate is a moving hygrometer or a stationary one over which a current of air passes. Some years ago I took up the subject of controlling humidity, and produced the instrument which is illustrated in this article. To indicate that the subject is new I would say that it was necessary for me to coin a word to designate the instrument which controls, and I named it the "Humidostat," which is in line with "Thermostat." To be of value the humidostat must be both delicate and powerful. It must be delicate, because it must perform its service so as to keep the humidity within a range not greater than 2%. Some nineteen years ago I devised a system of controlling temperature by thermostatic action, supplemented by compressed air. The humidostat acts nearly in the same way. The compressed air furnishes the powerful element for operating the valves which supply the humidity, and is itself controlled by the delicate mechanism which is affected by the moisture in the air. How this is done is shown in Fig. 1. An iron wall-fastening is firmly attached to some wall or other support and two air lines are brought behind this support to a face-plate set in the upper part of this wall-fastening. To this plate is attached a main air supply of compressed air under a pressure of

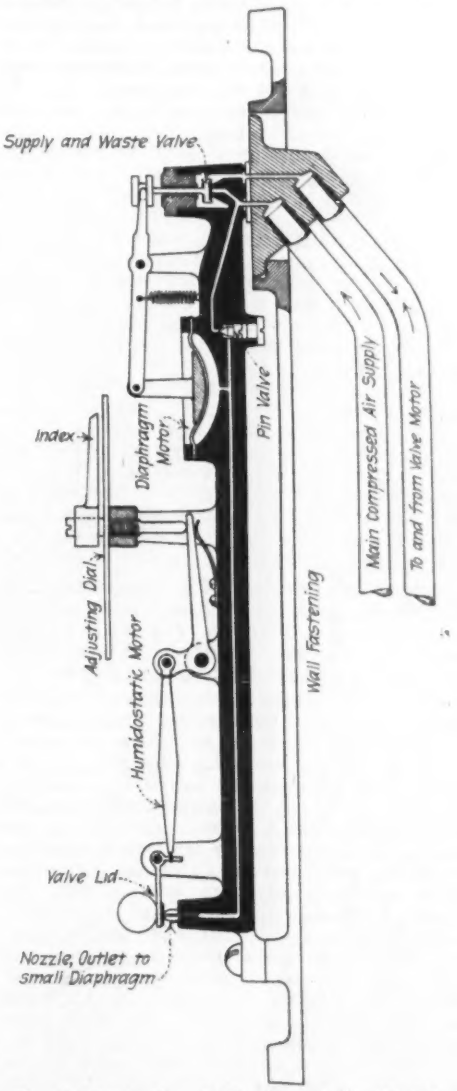


Fig. 1. Controlling Mechanism of Humidostat.

from 10 to 15 lbs. per sq. in. To this same face-plate is attached another air pipe which runs to the diaphragm motor controlling the steam supply. When compressed air is admitted to the latter pipe it enters the diaphragm chamber, shown in Fig. 2, on the steam valve. In pressing down on the diaphragm it closes the valve. When it is necessary that the valve should again be

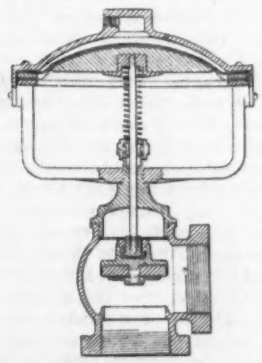


Fig. 2. Diaphragm Steam Valve.

open to supply steam the air escapes back through the face-plate, as will be shown further on: First, there is a supply and waste valve, which, in the position shown in Fig. 1, cuts off the supply of compressed air from passing further than the

*President Johnson Service Co., Milwaukee, Wis.

opening under the valve seat. When this valve is lifted up to its limit in the other direction it opens the supply port and allows the air to pass around into the pipe leading to and from the valve motor. The stem of this valve has a grooved head, in the groove of which a fork lever is extended over a fulcrum and has attached to it a plate or buffer, all as shown in Fig. 1. This buffer rests upon a flexible diaphragm, the movement of which operates the supply and waste valve. A branch of the main air supply passes downward through the body of the humidostat to a pin-valve, which may be regulated to allow any definite amount of air to pass. This branch continues into a chamber underneath the flexible wall of the diaphragm motor. It also continues to the lower part of the humidostat, where it has a small nozzle-like opening, which becomes the outlet for the compressed air which may be under the diaphragm motor. This nozzle outlet is covered by a valve-lid which prevents the passage of air when it rests on the nozzle. The ball attached to this valve-lid is for the purpose of holding the valve against the nozzle to prevent leakage. The valve-lid is attached by means of a bell-crank lever to a humidostatic motor. This motor consists of any suitable substance, which elongates under humidity and shortens on the removal of the humidity from the atmosphere. The opposite end of the humidostatic motor is also attached to a bell-crank lever, the long arm of which is moved by an adjusting screw. This screw has an index and moves over an adjusting dial marked with the percentages of humidity.

The apparatus shown by Fig. 1 is covered by an ornamental metal box, with perforated sides to admit the air of the room. The box is about 3 ins. wide, 10 ins. long, and stands out some 2½ ins. from the wall, all these dimensions being over all.

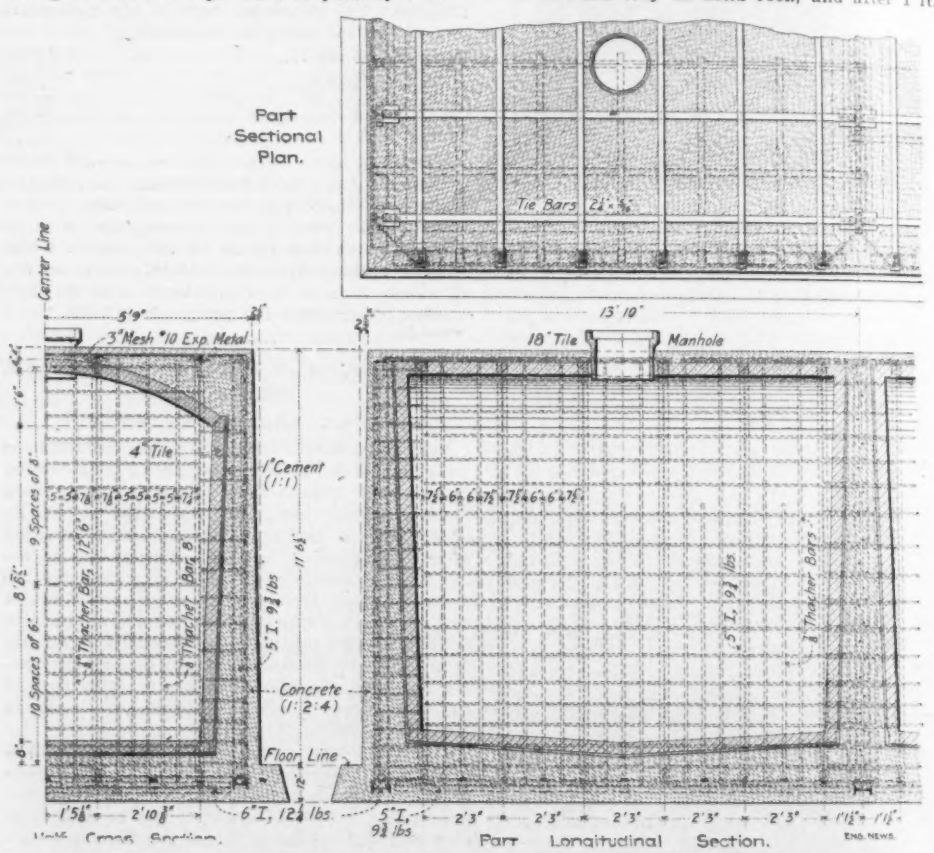
After the apparatus has once been adjusted, the upper end of the humidostatic motor remains fixed, and any elongation or contraction caused by change of humidity will operate upon the bell-crank lever to which the valve-lid is attached. As shown in Fig. 1, the valve-lid has closed the outlet to the small diaphragm, resting upon the nozzle. As compressed air can leak through the pin-valve, the chamber under the diaphragm motor is under compression, and through the means of the lever the supply and waste valve will be firmly over the outlet to the main air supply, and through the looseness of its stem will allow any compression which was on the diaphragm motor on the steam valve to escape and the steam-valve to be opened. The steam-valve may be used to allow steam to enter either the apartment or the air-ducts which lead to the apartment, or it may supply steam to a coil in a water-pan, the water being made to boil by the steam and give off steam itself. There is really no good reason for using the latter method when steam from ordinary power boilers can be had direct. In the position of the parts shown in the drawing, the steam-valve being open, the humidostat is in a condition to operate to shut off the steam when the humidity of the apartment is sufficiently high. This result is obtained as follows: The humidostatic motor, lengthening by humidity, pushes upon the bell-crank lever at its lower end, presses the valve away from the outlet to the small diaphragm. This outlet is larger than the supply of compressed air entering through the pin-valve. The diaphragm motor collapses; the lever is pulled down by the spring which moves the supply and waste valve to its opposite position. This allows the main air to pass to the diaphragm on the steam-valve and closes the steam-valve. The parts will remain in this position until the humidity in the room falls from 1 to 2%. This will contract the humidostatic motor, allow the valve-lid to close the outlet to the small diaphragm, and the compressed air to enter through the pin-valve. This will push out on the diaphragm motor and again place the supply and waste valve in the position shown in the cut. From the loss of compressed air, the diaphragm motor of the steam-valve will then collapse and the supply of steam be again renewed. This process continues indefinitely, the range of humidity being from 1 to 2% only in variation.

It is evident that the same humidostat will operate any sized steam-valve to which it may be attached, and thus we have both delicacy and power. The experience of some years has shown that the humidostat can be relied upon to do the work and keep its range of humidity in very close limits. As humidity travels in all directions the same as gas in a vacuum, one humidostat serves to control in very narrow limits, the humidity of a very large space. For instance, if all the heated air for a school building be supplied from a single source, and steam be allowed to enter the general duct for the building, one humidostat placed in one of the rooms of the building would be sufficient to regulate the humidity within 1 or 2% for all the rooms of the building. I have a case in mind where a school having 40 rooms has but one humidostat. The humidity never varies more than 1 or 2% in any of the rooms.

CONCRETE-STEEL TANKS FOR ACID LIQUOR UNDER PRESSURE.

By A. C. Arend.*

The accompanying drawings show the general details and arrangement of a group of three tanks designed to hold a liquid of specific gravity 1.5, and which would at times evolve chlorine gas causing an additional pressure of possibly 5 lbs. per sq. in. upon the inside surface of the tanks. The general requirements were that the tanks were to be filled to a depth of 8 ft. with any one or all of them full at the same time; that they be of proper dimensions to utilize a 4-in. thick glazed tile lining, which had already been ordered to the dimensions marked on the drawing, the sole object of which was to resist the chemical action of the liquid; and that there be used in so far as practicable, a quantity of I-beams, which had already been ordered for the previous design.



PLAN AND SECTIONS OF REINFORCED CONCRETE TANKS FOR LIQUOR UNDER PRESSURE.

The final design was started about Nov. 10, 1903, and it was desired to have one tank completed to a point as high up as the feet of the roof arch by Dec 15, at which time the tile lining was expected to arrive.

These conditions and requirements made it essential that all additional materials required must be found in stock, and that the details should be of such a nature that they could be [illegible] and assembled by the mechanics and [illegible] shop facilities with which the plant was [illegible]. This was quite a limitation. Flat bars were used for ties rather than rounds to save [illegible] work; they were ordered Nov. 19, received the next day, and drilled to suit in our machine shop. The angle clips and gusset plates were ordered cut to the required lengths—where sizes were found in stock; were shipped on Nov. [illegible] received promptly, and drilled to suit in our machine shop. The "Thacher bars," claimed to be in stock, were ordered cut to the required lengths Nov. 26, shipped Dec. 5, received Dec. 14, and sent to suit by our blacksmith. The ½-in. bevel washers required for I-beam flanges could not be found in stock, and were cast from our own pattern in the local foundry. The lot of I-beams, which had already been ordered from mill on Oct. 25, were shipped on Nov. 25, and received Dec. 9; when they were drilled, coped, etc., to suit in the machine shop. The design had been made to suit the lengths as ordered, and it used all but two. Expanded metal in 6 × 8-ft. sheets was ordered Nov. 14 and received promptly. The sand, stone and cement were ordered from stock held by local dealers.

The footing below floor level consisted of about 4 ft. of hard clay on solid rock, and after 1 ft. of this had been excavated it was decided to have the tank bottom finished one foot higher above the floor line, and the foot which had been excavated was replaced with concrete in the proportions of 1 — 3 — 5. The tanks as shown were constructed on top of this, making the top line 12 ft. 6½ ins. above the floor line, or 1 ft. higher than designed.

The sill beams were blocked up on this footing course—as soon as it was hard enough—all framing and ties connected and braced in place; and "Thacher bars" wired or fastened in place, excepting those in the middle bay of one end wall, and the two partitions, which ones were left out until the concreting had been finished up to the grouting lines of the tank floors. As soon as this was hard enough to work upon the forms for the walls were erected and braced in place—complete on the insides and partitions and in about 4-ft. high courses as the concreting progressed on the outside.

All concrete was mechanically mixed, each

*111 Massachusetts Ave., Buffalo, N. Y.

batch being charged as follows: 1 barrow of stone (2 cu. ft.), 1 pail water, 1 barrow of sand, 1 bag cement, ½-pail water, and 1 barrow of stone. The concrete was dumped on a platform alongside of the tanks and carefully shovelled in place and tamped around the bars. The work had been completed on Jan. 1, 1904, as far as was possible before placing the lining tiles in position.

The accompanying drawings require brief explanation in order to make the construction of the tanks perfectly clear. As will be seen, the tanks are rectangular in form and are roofed over; they are set side by side. The main reinforcing frame for each tank consists of I-beam sills and I-beam wall columns, which are tied together in both directions across the bottom and top by means of flat bars. Between sidewall columns there is a reinforcement consisting of intersecting upright and horizontal Thacher bars. Similar bars are used to tie the adjoining walls together diagonally across the corners. The roof is reinforced by a horizontal layer of expanded metal. With these brief statements the drawings may be readily understood.

SOME OBSERVATIONS OF SEWAGE FARMING IN ENGLAND.

(Editorial Correspondence.)

Sewage farming in England has by no means come to an end, although in many instances it is being abandoned as rapidly as local circumstances will permit. My impressions thus far are that sewage farming in this country has been practiced under conditions that more often than otherwise have been naturally adverse; and that to these natural drawbacks have been added such artificial ones as a sacrifice of sanitary results to farm and dairy produce, while perhaps the greatest drawback of all has been a lack of well-directed scientific knowledge in both the design and operation of sewage works. Heavy clay soils, land with too little slope to admit of the proper distribution of sewage, and the proper drainage of effluent, a moist climate with comparatively little sunshine, the desire to show a profit instead of merely reducing the inevitable expense of sewage disposal, mistakes in laying out land and in conducting the mechanical operations of handling sewage and sludge, ill-chosen methods of farming and of marketing farm produce—all these conditions rather than the inherent defects of the system are largely responsible for the ill-repute into which sewage farming has fallen in England.

Not a little of the apparent failure of sewage farming here has been due to the faulty methods employed as preliminary to the application of sewage to the land. Where the land available for sewage farming is defective in quality or deficient in quantity, it has been necessary to resort to a preliminary process of sedimentation, chemical precipitation, or some method of filtration, and this necessity has furnished the opportunity for exploiting the conceits of visionaries and of the proprietors of a multitude of patented processes of sewage treatment. Most of these processes have proved either futile or ruinously expensive, but too often the condemnation for their failure has been heaped on sewage farming instead of on the preliminary treatment.

It should be explained for the benefit of those unfamiliar with the history of sewage treatment in England and Wales, that for years past the Local Government Board, which controls most municipal improvements involving loans, has insisted on the final application of sewage to land, regardless of the previous method employed to treat the sewage. This has virtually made sewage farming a necessity, wherever any departure from discharging crude sewage into a stream or the sea has been adopted. Acting under compulsion, it is not strange that municipalities and their engineers and farm managers should often lay out and operate sewage farms in a makeshift fashion, particularly since in most parts of Great Britain, notwithstanding the Rivers Pollution Act, there is little or no central control of the character of the effluent from sewage works. Important exceptions to this lack of control exist, particularly when the effluent is discharged into the drainage area of the Thames, from which river most of the water supply of London is taken.

I have written this resumé of facts and of my own observations relating to sewage farming in England in order that the readers of ENGINEERING NEWS outside of Great Britain, and particularly in America, may the better understand why there should have been, in the last few years so much haste in adopting bacterial methods of sewage treatment in a country where sewage farming has been and still is so extensively practiced. Since sewage farming has never really gained a foothold in America, the many attempts to cut clear from it in England, whether due to adverse natural conditions, poor engineering and farm management, or the inherent defects of the system itself, can have little or no bearing upon the wisdom or folly of adopting septic tanks, contact beds or percolating beds in America. While my own observations lead me to believe that sewage farming here has suffered unjustly at the hands of both its friends and its enemies, I think even less favorably, thus far, of its chances of success in America than before I had studied its workings in England. In the Arid West, and in some sections of the East; in short, wherever it is desirable to make good a water supply insufficient for profitable agriculture, the application of sewage to crops might make a profit which would reduce the expense of sewage disposal. Doubtless there may also be cases where it would prove worth while to raise crops on land laid out to receive sewage, but I have seen nothing yet to convince me of the wisdom of out-and-out sewage farming in America.

None of the so-called bacterial methods, on the other hand, impresses me as being the universal solution of the sewage disposal problem. In so far as they result in a concentration of area, combined with a simplification in process, including in the latter a reduction in both labor and mechanical appliances, they are certainly promising. Judiciously chosen, there seems to be little doubt of their sanitary efficiency, both in absence of nuisance and possible purity of effluent.

I shall have more to say of the so-called bacterial processes later on, but before describing a few of the sewage farms which I have visited, I will take space to explain why I so frequently write "so-called bacterial processes": It is because of the misleading appropriation of the adjective "bacterial" to include a portion only of the methods of sewage treatment which depend wholly upon bacterial action. Sewage farming depends primarily upon bacterial action, but the growing crops relieve the land of portions of both the organic matter and the moisture in the applied sewage. Intermittent filtration, as developed experimentally by the Massachusetts State Board of Health, and practically at many sewage disposal works in Massachusetts and elsewhere in America and in other countries, is as truly a bacterial system of sewage treatment as any of the contact or percolating beds developed from it in Great Britain and elsewhere, except that the rate of treatment per unit, as proved after many years of practical trial, is less than is claimed by the advocates of contact and percolating beds and less than in those beds—mostly on a small scale—that have, for a few years, been in practical operation.

The septic tank simply utilizes sedimentation to rid the sewage of a part of its suspended matter, and anaerobic bacteria to reduce some of the organic portion of the sedimentary to gaseous and hydrolytic forms.

Broadly speaking, therefore, bacterial processes really include sewage farming, intermittent filtration, contact and percolating beds, septic tanks and even dilution by fresh or salt water. The only processes of sewage treatment which do not involve bacterial action, therefore, are sedimentation, chemical precipitation and mechanical straining.

NOTES ON SEWAGE FARMS.

For some years past nearly all the printed matter relating to sewage disposal in Great Britain has either contained no reference to sewage farms or else has spoken of them as being abandoned as rapidly as possible. The chief exception to this was a defense of sewage farming* made two or three years ago before some public gathering by Lieut.-Col. Alfred S. Jones, Assoc. M. Inst. C. E. Among my various letters of introduction I was most fortunate in having one to Colonel Jones, who has very kindly taken me to see three sewage farms, besides a fourth sewage works where sewage farming has been abandoned for so-called bacteria beds. Two of the farms visited are managed by Col. Jones, who also has one or two others in his charge, all under the War Office.

*This paper with another on a kindred subject was published in book form and reviewed in the Engineering Literature Supplement for April, 1903.

THE READING SEWAGE FARM.—This farm now comprises 869 acres, of which 450 receive sewage and 380 are underdrained. It was laid out some 30 years ago by Mr. James Mansergh, M. Inst. C. E., and for the past 15 years has been in charge of Mr. Thos. Chettle, as Farm Manager or Bailiff. Mr. W. M. Colebrook is Chairman of the Council Committee responsible for the farm. Mr. Chettle lives in a comfortable house on the farm, which also shelters the farm offices.

Reading, which lies between London and Oxford, had a population of 72,217 in 1901. Its area is 5,278 acres and its sewers are on the separate plan. Some of the early sewers were laid with clay joints and admit ground water more freely than do the others. The maximum daily flow of sewage is given as 3,300,000 U. S. gallons, and the minimum as about 2,500,000 gallons. Judged by its looks, the sewage is stronger than that of most American cities, and well broken up in its flow to the farm, which flow is mostly due to gravity. My visit, I may add, was made at about 3 p. m., on the afternoon of Tuesday, March 29, just after a heavy shower, preceded by a long, wet winter. The day was cool and although much of the land was very wet, I noticed scarcely any sewage ponding. The apparent freedom from ponding and "sewage sickness" indicated that the land was well graded and the sewage carefully applied.

The effluent from the farm goes to the Kennett River, a small headwater of the Thames, and therefore under the jurisdiction of the Thames Conservatory Board. An inspector from the board visits the farm frequently but at irregular intervals. In a recent year the visits numbered 32, and in another 47. Samples for analysis are taken in duplicate from four points once every two months. The duplicate samples are left with the Reading authorities. Copies of the results of the analyses are not sent to the municipal authorities unless requested or unless the effluent is bad.

Since Christmas, 1903, the farm has suffered from four heavy floods and two light ones, the worst of which flooded 600 acres of the farm. No such bad floods have occurred before since 1894, but apparently much of the land, even in years of low water, is not sufficiently above the river to give the best results. Many of the underdrains are quite near the surface, and much of the time they are under water.

The staple product of the farm is milk, which is sold to Reading retailers at a yearly average price of about 9d. per Imperial gallon, or about 3.75 cts. per U. S. quart. There are now nearly 300 cows on the farm. Horses for farm work are home bred, and Mr. Chettle appears to be deeply interested in horses and horse breeding.

The main forage crop is Italian rye grass, which is sown anew once in two years. Four to six crops of this grass are cut each year. The first crop was to be cut soon after my visit, but to me it seemed very short; perhaps the shortness was due to the long wet winter. Large quantities of mangels are also raised to feed to the cows.

An average of 70 men and boys are employed on the farm, running to 100 in harvest time. Practically all the reaping is done by hand, as much as possible by the piece. The rye grass is also cut by hand. The regular weekly wage for men permanently employed is 16 shillings, or a trifle under $4, besides house and garden and 80 shillings, or nearly $20 extra, at Michaelmas. Men employed by the day are paid 3 shillings each, with an extra shilling for cutting grain and 4d. per hour for overtime. The hours for these men are from 7 a. m. to 5 p. m. in winter, and from 6 a. m. to 5.30 p. m. in summer.

There are 23 cottages on the farm, with perhaps an average, including boarders, of 8 persons in

each. During the last 15 years, Mr. Chettle stated with pride, there had been only one case of typhoid fever on the farm.

The farm has shown a profit in some years, but on the whole it has been run at a loss, and the loss, instead of being charged to the net cost of sewage disposal, and met by taxation, has been carried as a debit balance in the hopes of better profits in the future. A reform in financial methods is now under consideration, including not only an adjustment of the deficit, but also a broad study of the administration of the whole farm, with a view to improved financial results. The council committee in charge of the farm visited Manchester with a view of judging the advisability of adopting so-called bacterial methods of treatment, but it finally concluded to make the most of its large sewage farm. To aid it in this matter it has appointed an advisory committee consisting of Col. Jones, who is chairman of the committee, Mr. Arthur Avis, Manager of the Nottingham town sewage farm, and Mr. B. W. Farmer, of Little Bidwell, Berkshire, a farmer and land owner, who has some 20,000 acres of land under his charge. Among other things, this committee will probably recommend that sewage be pumped to some high land not otherwise available for the reception of sewage.

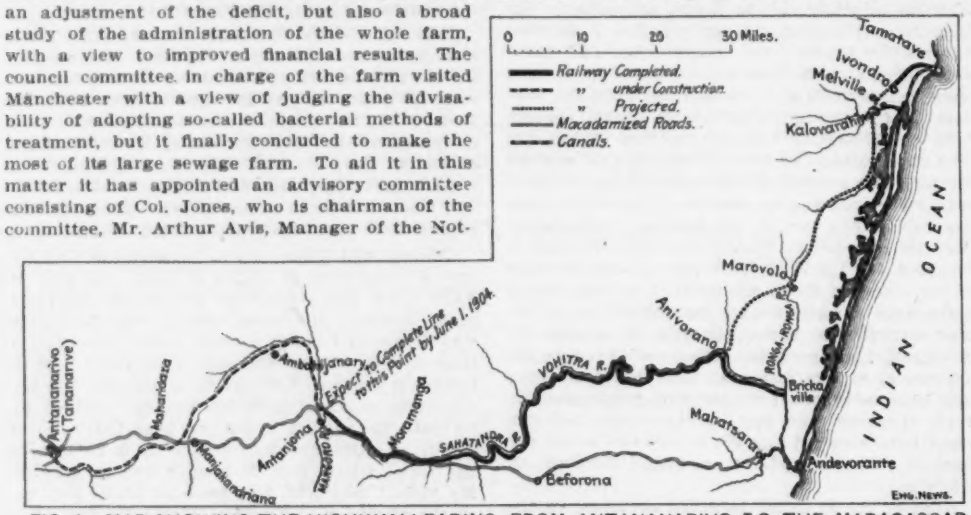


FIG. 1. MAP SHOWING THE HIGHWAY LEADING FROM ANTANANARIVO TO THE MADAGASCAR COAST; AND THE RAILWAY SYSTEM, BUILT AND PROPOSED.

I take it that this farm is an admirable illustration of some of the difficulties in sewage farming in England: (1) Only a little more than half of it is under sewage, and a large portion is subject to the evil effects of high water; (2) there has been a tendency to place farming profits before sanitary sewage disposal. I thought it evident, from conversation with Mr. Chettle, that he much preferred farming without sewage to farming with it, and that he was interested mostly in stock breeding. I hope we may learn in America what comes of the deliberations of Colonel Jones' committee and its recommendations. I am inclined to think that his strong personality, combined with his admirable management of the two nearby sewage farms described below, and the fact that he is on the managing board of a large hospital at Reading, have all combined to influence the Reading authorities to continue their sewage farming operations a while longer, instead of turning to septic tanks and contact or other artificial methods of sewage treatment. Credit must also be given to Mr. Chettle's farm management and to the courage and enterprise of the Reading authorities, who, besides building up their large sewage farm, have many other municipal undertakings in hand.

THE SANDHURST MILITARY SCHOOLS SEWAGE FARMS.—After spending the night at Ridge Cottage, as Colonel Jones modestly calls his home on a commanding ridge with a fine outlook over a broad valley and to distant hills, we started out, on the morning of March 30, to visit three different sewage works. I may add, as an illustration of the many sewage works within some small areas in England, that we passed close by a fourth on our short journey.

The first visit of the morning was to a tidy little farm of only 13 acres, which receives the domestic sewage of about 1,000 persons, composing two military schools in the Parish of Sandhurst. Practically all this land receives sewage. The underdrains, which are laid to a depth of 2 to 3 ft., discharge into the Blackwater River, included in the Thames drainage system.

The sewage is received in two small concrete deposit tanks, used alternately, each perhaps 6 ft. wide, 15 to 18 ft. long, and from a few inches to 3 ft. deep. The sewage enters the deeper part of the tanks and discharges in a thin sheet over a level space at the shallow end. The sludge settles in the deeper part of the tank, from which it is removed about once a week onto adjacent land, where it is retained by a rough, low embankment until it has partly dried out.

Most of the regular work on this farm is done by an old man, whose wage is four shillings, or about a dollar a day, and the use of a tiny cottage in addition. The cottage is entered through its tiny a front garden, and a large part of one side of the brick wall of the building was covered by the cheery red blossoms of a creeper. Notwithstanding this poetic exterior, the living room of the cottage seemed damp and close, and suggested the desirability of higher ground.

Italian rye grass, oats and mangels are raised on the farm and sold to the Aldershot Camp, near by, or to other purchasers. Horses and laborers come from the Camp to do the plowing and like work, and a gypsy boy was engaged, at the time of my visit, to scare away rooks from a newly-sown oat field.

The effluent from the underdrains was clear, and except for one or two light whiffs as I went over the farm no indication of sewage was noticeable. Colonel Jones has managed this farm since 1896, and it was a pleasure to see how well everything seemed to have been conducted.

ALDERSHOT CAMP SEWAGE FARM.—This farm, as has been well said, may serve to illustrate the results of both good and bad management. Originally laid out in 1865, it was operated for nearly 15 years with satisfaction. Then was badly managed for about an equal period under a lease to a dairyman. Colonel Jones took charge in 1895, and again put it in excellent condition. The difference between the good and bad management represent the extremes of sewage farming as a sanitary operation and as a source of profit alone. Perhaps no one thing has contributed more to good results here than the care exercised in grading the land and in laying out the distributing channels, both of which were treated by Colonel Jones as engineering problems. In fact, his whole management of the farm shows the mind and directing hand of the engineer.

The Aldershot Camp Farm, as it is generally called, now includes 132 acres of land, of which 121 acres are available for irrigation. It has been underdrained to a depth of 3 to 6 ft. The land was originally a waste place of deep sand, and it is close by a military hospital. The managers of this hospital had been working for the abandonment of the farm, prior to the time Colonel Jones took hold of it, but are now, it is said, quite satisfied to have it almost beneath their windows. The population of the Camp varies from 20,000 to 30,000, besides which the drainage from stables for some 2,000 horses goes to the farm.

The sewage from different parts of the Camp is received at three points in deposit tanks, similar to the one at Sandhurst, but larger, and having before them small grit or detritus chambers. The deposits in these chambers are stirred two or three times a day, to reduce the amount of organic matter retained therein. One set of deposit tanks, remote from the highway, has been used as an open septic tank since 1901, without cleaning. The other two sets are provided with screening bars between the grit chambers and the tanks, and the sludge is sluiced away about once a week in open channels and built up with straw and cow manure into compact heaps, above the ground level. One of the deposit tanks is close by the highway and is separated from it by an open fence only.

The chief sources of revenue of the farm are milk, green forage, and the sale of fattened cows. Cows are bought when fresh in milk, milked for about 15 months, fed for a month or so to complete the fattening begun while they are getting dry, and then sold for killing.

The standard herd is 48 cows, but not so many cows are kept in winter as in summer. For the year 1902-3 an average of 34.4 cows were kept and produced an average of 912 U. S. gallons of milk each. The preceding year the corresponding figures were 36.6 cows and 917 gallons. The milk is sold to the military hospital and camp.

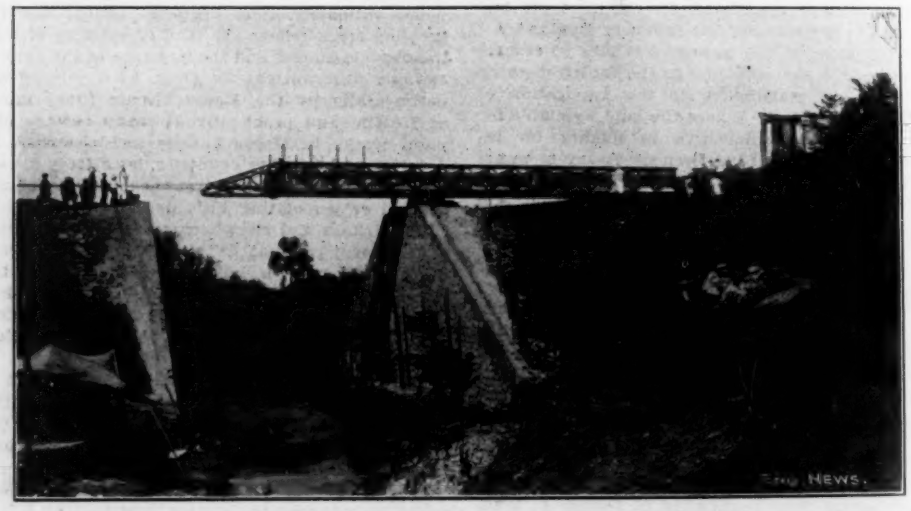


FIG. 2. MADAGASCAR RAILWAY; ERECTING A BRIDGE OF 49-FT. SPAN OVER THE SANDRAKA RIVER.

The dairy house has a cemented floor, apparatus for cooling the milk, a steam jet and a boiling vat for the milk cans. The cowhouses are commodious, with about 2,000 cu. ft. of space per cow. The gutters behind the cows are of concrete, finished with cement mortar, as are also the combined water and feed troughs in front of the cows. The standing room for the cows has its rear part paved with notched brick and its front part covered with rammed chalk, to keep the cows from slipping and to prevent injury to their knees.

when they lie down or get up. Both the feed trough and the manure gutter are flushed out with water daily. The manure is thrown under a shed and covered with straw. The cowhouse walls are of brick and the inside walls and ceilings are whitewashed.

The recently built workmen's cottages are of brick, but some of the earlier ones were of corrugated iron. The cottages are too small for the large families of farm laborers, being modeled after those designed for married soldiers and having only two sleeping rooms. Larger cottages would make it easier to keep the farm laborers permanently.

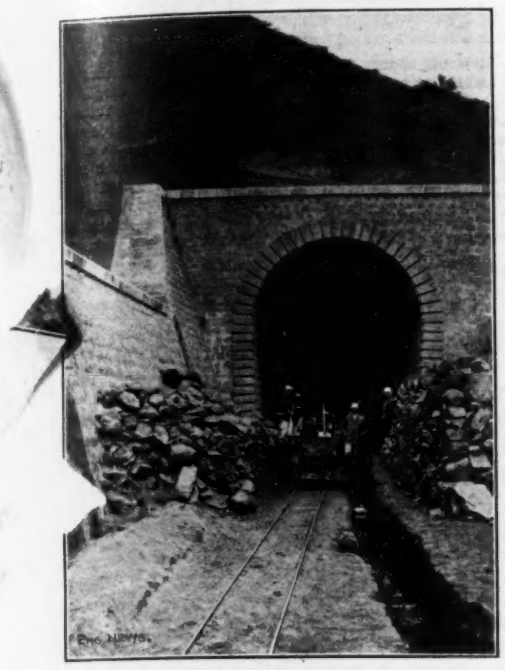


Fig. 3. Madagascar Railway. Tunnel at Antanifatsy; now used by the highway, but will be later devoted to railway purposes.

On walking over a large part of this farm, I saw only one small field which showed evidences of sewage ponding, and presumably this was due to the bad winter which has just passed. No odors were observed, not even at the septic tank. The effluent was clear. It discharges into the Blackwater River and finally into the Thames, and thus the farm comes within the jurisdiction of the Thames Conservancy Board. I saw a number of copies of the results of analyses of samples of effluent taken for the board. The invariable comment, if any, under "remarks," was "not a bad effluent," which seemed to be as far as the board was willing to commit itself.

From the Aldershot Camp Farm I went with Colonel Jones to the town sewage works, which are operated conjointly with a refuse destructor. The heat from this destructor is used to pump the sewage to the filter beds which have superseded chemical precipitation and sewage farming, and of which I may write later. At present I will only say one set of coarse beds, 4½ ft. deep, are used as contact beds, and that the effluent from these goes to beds of finer material, only 1½ ft. in depth, operated like our American intermittent filters. The coarse or contact beds have a top layer of fine material, which is scraped with shovels and deeply forked about once in two weeks.

I will conclude this letter by saying that directly after my two days with Colonel Jones, I went to Birmingham and enjoyed to-day an interesting tour of inspection with Mr. John D. Watson, Engineer of the Birmingham, Tame and Rea District Drainage Board, which owns some six square miles of sewage farms in the Tame Valley, on which is treated the sewage from a number of municipalities with an aggregate area of 90 sq. miles and a total population of 720,000 in 1901. In 1900, Mr. Watson abandoned chemical precipitation for plain sedimentation and septic treatment, and he is now constructing Dortmund tanks to remove the suspended matter carried forward by the septic tank effluent, and percolating beds for the final treatment of the Dortmund tank effluent. Eventually the large area of land owned by the district will be used only for the treatment of storm water and for digging in sludge from the sedimentary deposit tanks which precede the septic tanks. For the latter purpose alone a hundred acres of land are now required for a year's operations.

M. N. B.

Birmingham, England, March 31, 1904.

THE RAILWAY AND TRANSPORTATION SITUATION IN MADAGASCAR.

The important island of Madagascar—the third largest island in the world—is 980 miles long, north and south, and nearly 250 miles wide at its broadest part. The greater portion of its area is covered by an intricate system of steep mountains, making it one of the most irregularly mountainous regions in the world, with a general elevation of about 4,000 ft. above the sea for this central district. On this interior plateau the climate is very salubrious, much resembling that of Southern Europe, and the soil is well adapted to the production of native food products, such as rice, maize, sweet potatoes and manioc. The lowlands skirting the coast, on the other hand, are tropical in climate and notoriously unhealthy, owing to the large areas covered by marshes and lagoons.

In 1895 the French finally conquered Madagascar, after a long and costly struggle, and since that date the chief economic problem confronting the conquerors has been the creation of means of transport in this much broken and difficult country. Connection between the coast ports and the capital city of Antananarivo—or Tananarive, as the French call it, was an absolute essential to any development; and an excellent macadamized road, about 145 miles long, was opened to traffic in January, 1901, leading from the capital to Mahatsara, at the head of river navigation leading to the port of Andevorante. As the crow flies the distance to the coast is only 100 miles; but the engineering difficulties overcome in constructing this road were very great.

But a railway connection with the interior was still more necessary, and the accompanying map shows the progress made in this direction. In April, 1900, France authorized a loan of 60,000,000 francs to the government of Madagascar; and of this $11,580,000, $9,264,000 was to be devoted to railway construction, and the remainder to the building of other public works, such as roads, telegraph lines, etc. As planned, the railway will be 171 miles long, and in this distance it must ascend from the sea-level to an elevation of 4,000 ft. above the sea. About 21 miles of this line were opened to traffic some time ago; by June 1 of this year it is expected that the line will be open to the Mangoro River, and it is proposed to have the railways in operation to Antananarivo by 1908. The present coast terminal is located at Brickaville, connected by river navigation with the port of Andevorante. Much work has been done on the other sections of the railway, including a tunnel through granite, 2,400 ft. long, one half of which is now driven.

This port of Andevorante is in communication with the more important port of Tamatave by means of a system of canals connecting the lagoons which line the coast for the 72 miles lying between these ports. The canal commences at Ivondro, 8 miles south of Tamatave, and a railway connects Tamatave with Ivondro. This canalization of the lagoons has not been a very successful undertaking, as the currents produced by the canals favor silting and much dredging is required to keep the waterway open. The canals were built by private parties and the results indicate that a coast railway would have been a better and more useful enterprise.

The government has recently inaugurated an automobile mail service between the capital and Tamatave; the automobile using the highway to Matatsara, the remainder of the trip being made on the canalized lagoons. The journey between the two terminals is made in about 48 hours.

The chief port on the west coast of Madagascar is Majanga; and a fine road is now in course of construction leading from this port to the capital. The distance is greater than to the east coast, and the engineering difficulties are quite as great; but the gradients are less steep. This highway will open up to traffic a great area of country, and especially favor trade with East Africa. Arrangements have already been made with the British India Steamship Co. for a monthly service between Majanga and Durban, Lorenzo Marques, etc.

FIG. 4. MADAGASCAR RAILWAY. GRADING FOR A STATION; LABORERS' QUARTERS TO THE RIGHT.

(This view conveys some idea of the mountainous character of the country traversed.)

TESTS OF SAND-LIME AND SAND-CEMENT BRICK AND CONCRETE BUILDING BLOCKS.*

By A. Marston.†

In the manufacture of building materials there have recently been two important developments which have attracted much attention from brick manufacturers. These are the manufacture of sand-lime brick and of concrete building blocks. Believing that some information regarding the physical qualities of concrete building blocks would be of interest, the Civil Engineering Department of the Iowa State College has recently made a series of tests of the products of three Iowa factories, and the results are given herewith in tabulated form. The specimens furnished were hollow building blocks of the usual standard dimensions to fit in with brick of the usual size. The tests of one sample of sand-lime brick are also presented. The concrete blocks were obtained through the courtesy

*Abstract of a paper read at the January, 1904, meeting of the Iowa Brick and Tile Manufacturers' Association.

†Professor of Civil Engineering, Iowa State College, Ames, Iowa.

of the companies which made them, which courtesy is here gratefully acknowledged, while the sand-lime brick was furnished by Mr. J. B. McGorrisk, of Des Moines, Ia., and came originally, so the writer understands, from some eastern representatives of the Huennekes system.

All the tests were made in the standard methods developed in the civil engineering testing laboratories at the State College. In general the procedure in transverse tests was to support the concrete block or brick near each end on rounded knife edges with steel bearing blocks to prevent cutting in of the knife edges, and to apply the load to a similar but adjustable knife edge and block at the midway point on top. In the crushing tests of large shapes the specimens were bedded in plaster of Paris and allowed to set four hours. In these tests and in the transverse tests the blocks were placed in the machine in the same position in which they would stand in a wall. In the transverse tests of brick the specimens were placed flatwise. The crushing tests of 2-in. cubes were made between adjustable steel bearing surfaces. In calculating the crushing tests of the large shapes, the results expressed in tons per square foot were determined without allowing for the hollows in the concrete blocks, while for the results expressed in pounds per square inch the hollows were deducted in making the computations.

The absorption tests were made on 1-in. cubes. These were thoroughly dried, then immersed in water and weighed at intervals up to four days, with the results shown in the table. On completion of the absorption tests the same 1-in. cubes were used for the freezing and thawing tests. Each day all the 1-in. cubes were frozen for 20 hours, the temperature of the freezing box ranging usually from 1½° to 5° above zero, Fahrenheit, and then thawed for four hours in water heated to 150° F. At intervals of three days the specimens were weighed while still saturated with water in order to determine the approximate losses. Specimen No. 1c failed entirely at the third day; No. 2 at the sixth day; Nos. 6, 2c and 6c at the eighth day, and Nos 3, 4, 3b, 1a, 2a, 3a, 3c, 4c, and 5c at the end of the ninth day. The remaining seven specimens all showed serious disintegration at the end of the ninth freezing and thawing, and it seems probable that these also will be practically destroyed at the twelfth test, which is not yet finished.

The detailed tests of concrete blocks given in the table above may be summarized and averaged as follows:

Kind.	Crushing Strength. Transverse Modulus of Rupture, lbs. per sq. in.	Large shapes Tons per sq. ft.	2 inch cubes, lbs. per sq. ft.	% Absorption 48 hours	No. Freezings to destroy 1 inch
a	177	45.5†	1047	6.5	11
b	312	43.1†	829	7.0	11
c	177	42.5	1113	8.8	8
Average	222	43.7	996	7.4	10

Summary of Tests of Common Brick and [illegible] Building Blocks.

Kind.	Crushing Strength. Transverse Modulus of Rupture, lbs. per sq. in.	Large shapes Tons per sq. ft.	2 inch cubes, lbs. per sq. inch.	[illegible] 1 inch cubes.
Average of Four Mason City Hollow Blocks	....	54.8	....	....
Average of 6 Varieties of Common Brick	660	....	3370	[illegible] 47
Average of 3 Varieties of Soft Brick	300	....	1850	[illegible] 33

It would appear from the results of these tests that the crushing strength of concrete hollow blocks is ample for the loads which would be apt to be placed upon them in ordinary buildings. The material itself, as compared with brick, does not appear to be as strong, as regards either crushing or transverse pressures, and what is much more serious, it does not, when completely saturated with water, resist freezing and thawing nearly so well. The fact that the material of concrete blocks is much less porous than that of common brick, as shown by the absorption tests, is likely to be of considerable importance in assisting to partly overcome this last defect. While the durability under the conditions encountered in actual buildings can be finally decided only by actual use extending over a period of several years, yet the writer will watch with much interest the behavior of concrete blocks used for foundation walls, and exposed to freezing and thawing at the surface of the ground, where considerable moisture may be expected to be absorbed from the ground, from the dashing of rain and from the melting of banked snow.

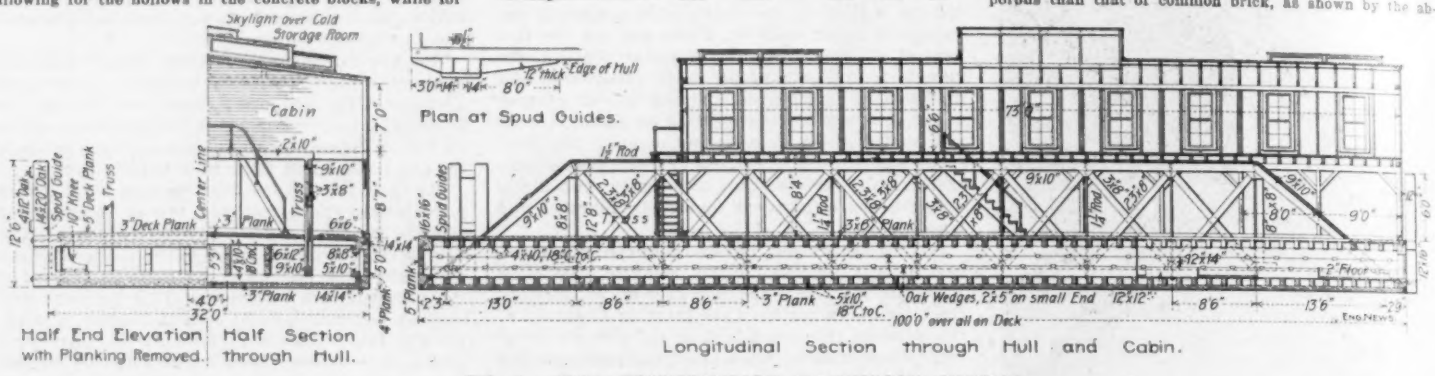


FIG. 1. HULL CONSTRUCTION OF MEXICAN DREDGE.

RESULTS OF TESTS OF LIME-SAND AND CEMENT-SAND BRICKS AND CONCRETE BLOCKS, CIVIL ENGINEERING DEPARTMENT, IOWA STATE COLLEGE, JANUARY, 1904.

Specimen	Proportion	Approx. Age Mo.	City	Number	Size	Crushing Test: Large Shapes Tons per sq. ft.	Crushing Test: Shapes lbs □″	Crushing Test: 2 in. Cubes lbs. □″	Transverse Test: Total Load lbs.	Transverse Test: Modulus of Rupture lbs. □″	Absorption Test: ½ m.	½ hr.	1 hr.	2 hrs.	6 hrs.	1 da	2 da.	3 da.	4 da.	Freezing and Thawing: Orig. Wt. gr.	Weight after 3 da. gr.	Weight after 6 da. gr.	Weight after 9 da. gr.	Weight after 12 da. gr.
Cement Sand Brick	1-3	....	Waterloo	1	4.06″x2.25″	....	....	660	850	373	8.1	9.1	9.6	9.8	9.9	10.1	11.5	12.1	12.1	33.9	34.5	20.0	15.3	*
" "	1-3	...	"	2	4.00″x2.25″	....	....	727	835	371	5.1	6.1	6.8	7.0	7.2	7.4	7.7	7.7	7.7	32.9	33.2	*		
" "	1-5	....	"	3	4.05″x2.27″	....	....	590	930	401	2.2	3.6	4.1	4.6	4.8	4.9	5.0	5.5	5.5	35.65	35.6	26.3	*	
" "	1-3	....	"	4	4.09″x2.25″	....	....	570	710	309	4.0	4.6	4.6	4.6	4.6	4.6	4.9	4.9	4.9	33.0	33.0	23.8	*	
" "	1-4	....	"	5	4.05″x2.25″	....	....	1809	790	347	.6	3.3	3.6	3.6	3.6	3.6	3.6	4.4	4.6	36.5	38 0	31.4	26.3	*
" "	1-4	....	"	6	4.13 ′x2.30′	....	....	1084	650	267	2.4	2.8	3.4	3.7	3.7	4.0	4.3	4.3	4.7	36.8	36.4	19.8	*	
Concrete Blocks	1-5	4.5	"	1b	10″x9″ x2′-6¼″	†48.0	880	974	5940	426	5.5	7.1	7.5	7.8	8.1	8.5	9.5	9.5	9.5	37.9	37.3	34.0	21.0	9.5
"	1-5	4.5	"	2b	10″x9″ x2′-6″	28.5	570	1145	4050	328	2.7	2.9	3.0	3.1	3.4	4.7	4.7	4.8	4.8	40.45	29.2	29.2	20.2	*
"	1-5	4.5	"	3b	10″x9″ x2′-8″	†48.0	930	859	3330	260	7.8	8.3	8.4	8.7	8.7	9.0	9.2	9.8	9.8	35.9	30.3	17.3	*	
"	1-5	4.5	"	4b	10″x9″ x2′-6″	†48.0	931	337	3000	235	3.0	3.3	3.5	3.7	4.1	4.6	4.7	4.8	4.8	37.9	37.7	21.3	19.5	*
"	1-4	1.7	Sac City	1a	8″x9″ x1′-3½″	....	....	1417	4300	196	3.2	3.7	4.6	4.9	5.4	5.4	6.2	6.2	6.6	40.1	39.3	33.5	*	
"	1-4	1.7	" "	2a	10″x9″ x1′-3⅛″	....	....	967	4600	158	2.1	3.2	3.5	3.7	4.1	4.3	5.2	5.4	5.4	35.15	30.7	30.0	*	
"	1-4	1.7	" "	3a	8″x9″ 1′-4″	45.8	899	800	....	....	7.5	7.8	8.0	8.1	8.5	9.0	9.9	9.9	9.9	32.4	27.2	26.4	*	
"	1-4	1.7	" "	4a	8″x9″ x1′-3⅜″	†48.8	963	815	....	....	4.5	4.6	4.8	4.8	4.9	5.5	6.0	6.3	6.3	39.0	29.5	28.0	23.0	*
"	1-4	1.7	" "	5a	8″x9″ x1′-3⅛″	41.9	841	1236	....	....	3.6	4.1	4.1	4.1	4.2	4.6	5.2	5.4	5.4	42.7	39.6	38.2	35.2	15.7
"	....	6.0	Webster City	1c	10″x9″ x2′-7⅝″	45.0	822	1430	1365	105	5.5	5.8	5.8	6.1	6.3	6.8	6.7	6.9	6.9	37.9	*			
"	....	6.0	"	2c	8″x9″ x2′-7⅝″	35.8	683	1270	1580	160	6.0	6.7	7.0	7.4	7.9	8.1	8.4	8.6	8.6	30.9	26.8	13.8	*	
"	....	6.0	"	3c	10″x9″ x1′-3⅜″	....	....	1250	3680	111	10.3	10.5	11.0	11.4	11.6	12.3	12.3	12.5	12.5	31.1	28.7	16.2	*	
"	....	6.0	"	4c	8″x9″ x1′-3⅛″	....	....	990	7440	330	7.4	8.2	8.2	8.5	8.7	8.7	9.0	9.1	9.3	34.6	33.4	18.2	*	
"	....	6.0	"	5c	8″x9″ x1′-3⅛″	48.7	950	930	....	....	6.1	6.3	6.3	6.3	6.3	6.4	6.9	7.0	7.0	40.0	34.9	30.2	*	
"	....	6.0	"	6c	10″x9″ x1′-4″	40.5	778	806	....	....	7.6	7.8	8.3	8.5	9.1	9.3	9.6	9.6	9.6	29.6	27.1	17.2	*	

Sand Lime Brick																				Weight after 4 da. gr.	8 da. gr.	16 da. gr.	22 da. gr.	28 da. gr.
				1	2⅜″x4″ x8⅜″	.....	....	2097	1600	635	....	....	....	.....	....	....	....	11.0	....	40.2	31.9	25.2	19.1	*
						....	....	3210	....	....	....	....	....	.....	....	....	....	10.9	....	42.05	27.7	28.4	21.8	12.5

*Entirely disintegrated. † Failed to crush at full power of machine.
½ of, (1b 2b, 3b, 4b, 1c, 2c) was crushed for the Crushing Test.

Cement brick behaved very much like the material of concrete blocks in the tests. The sand-lime brick tested was considerably stronger, and resisted freezing and thawing a little better, but did not test as good as common brick, especially in resistance to freezing and thawing.

COMBINATION HYDRAULIC AND DIPPER DREDGE FOR THE MEXICAN GOVERNMENT.

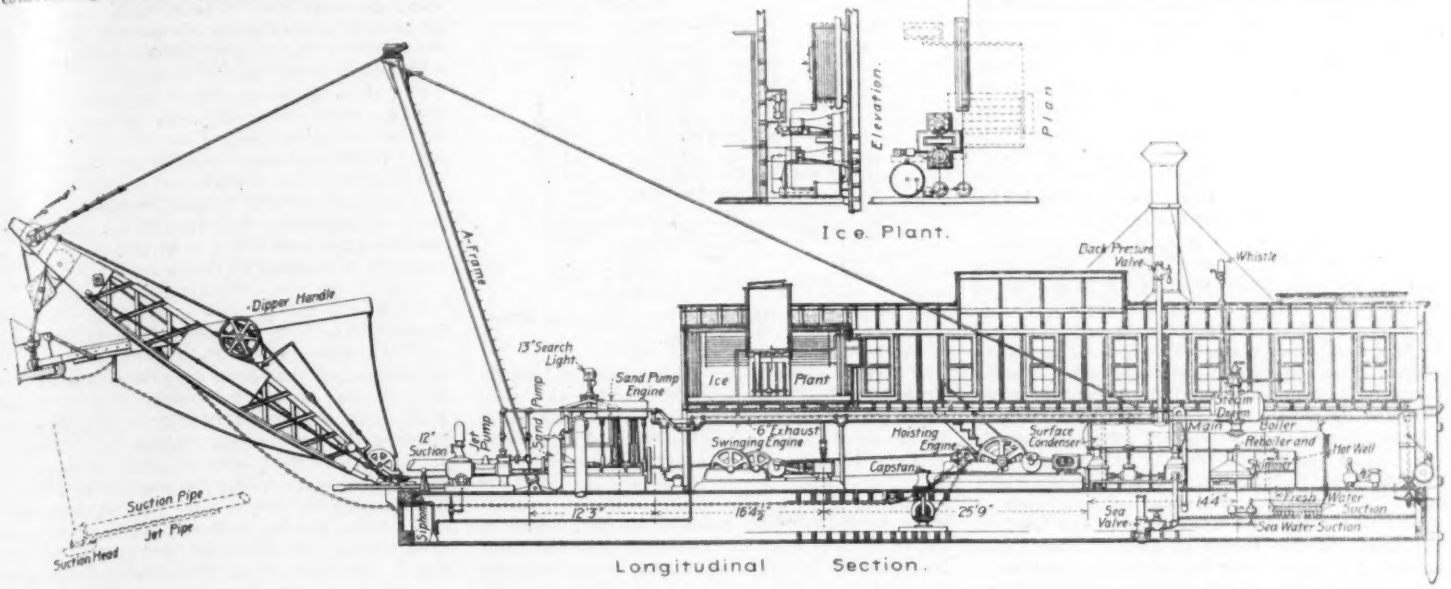
The port of Tampico, Mexico, is to be made one of the most important Mexican ports on the Gulf, and while the government is carrying out extensive harbor works, the Mexican Central Ry. is establishing large terminal facilities and constructing a direct line southwest to the city of Mexico. Among other improvements in this neighborhood, is the development of inland steamboat navigation with the port of Tuxpan, about 125 miles south, by means of canals and the existing lakes or lagoons. This will open up a region rich in timber and other products. A small canal already connects the Panuco River at Tampico with Lake Tamiahua, which is a salt-water lagoon lying parallel with the coast. This canal will be enlarged and new sections of canal cut to connect with other lakes and with the river above Tuxpan. A deep channel will also be formed through the lagoons. The Tampico and Tuxpan Canal will be about 125 miles long, 32.8 ft. wide on the bottom, and with a depth of 8 ft. at low water. The work is being done by the Public Works Department of the Mexican government, and the contract for excavation has been awarded to Mr. Charles E. Shillaber, C. E., of Tampico and Chicago. About 2,000,000 cu. yds. of excavation will be required, and the work is to be completed within five years. The cost of the work will be about $125,000.

Owing to the variety of hard and soft material to be handled, it was decided by the government engineers that a combination hydraulic and dipper dredge should be employed in the work, and a dredge of this character was designed and built by the Featherstone Foundry & Machine Co., of Chicago, to meet the general requirements of the engineers. The drawings of this interesting machine, with particulars of its construction, have been furnished us by the builders. It has been named "El Chijol."

The hull is 100 ft. long, 32 ft. beam and 5 ft. deep, with a draft of 36 ins. forward and 30 ins. aft. It is of selected southern pine, the material being shipped from the United States and put together at Tampico. For the knees, however, a local timber is used, known as "chijol," which is said to be as tough and durable as oak, and which is found in large quantities along the line of the canal. The floor timbers are 5 × 10 ins.; deck timbers, 4 × 10 ins.; forward timbers, 16 × 16 ins.; side timbers, 14 × 14 ins., and stern timbers 12 × 16 ins. They are all heavily framed and drift bolted. The planking is 5 ins. at the bow, 4 ins. at the sides, and 3 ins. at the bottom, stern and deck; but at the spuds and heel plates of the A-frame the deck planking is 5 ins. thick. To protect the timber from the attacks of the teredo, the hull is sheathed with creosoted planking 1 × 6 ins., a layer of tarred paper being placed between the sheathing and main planking. Four longitudinal bulkheads divide the hull into five compartments, and these are of timbers 6 × 12 ins. drift bolted together. Truss rods run from the top of the sides under the bulkheads, and are set up by turnbuckles. To stiffen the shallow hull longitudinally, so as to enable it to sustain the heavy weights and the severe working stresses, there are two longitudinal timber trusses, 13 ft. deep; these are 6 ft. from the sides. The two side spuds at the bow and the stern spud are all carried by guides outside the hull. All the machinery is on the deck, above which is a timber superstructure containing the living quarters for the officers and crew. The hull construction is shown in Fig. 1.

The machinery equipment and its arrangement are clearly shown in Fig. 2. At the bow is the boom for the dipper, and behind this is the centrifugal pump or sand pump for the hydraulic dredging, together with the pump for forcing jets of water through the suction head. Just behind the turntable of the boom is the leverman's house, and behind this are the swinging engines. Beyond these again are the hoisting engines, and then the boiler, with surface condenser at one side, and the electric generator and a small auxiliary boiler on the other side. Two capstans are driven by bevel gearing from a shaft driven from the hoisting engines by a chain gear. In the superstructure is the refrigerating and ice making plant.

The main boiler, rated at 90 HP., is of the locomotive type 16 ft. 10 ins. long over all, and is designed for a working pressure of 100 lbs. The firebox (which rests on a foundation bed of steel rails on the floor of the hull) is 58 × 57¼ ins. inside, and has a curved crown sheet. The barrel is 66 ins. diameter, of ⅜-in. plates, and contains 88 tubes 3 ins. diameter and 9 ft. 6 ins. long. Over the barrel is a horizontal cylindrical steam drum, 3 × 5 ft., with flanged heads. This is connected to the boiler by a 15-in. leg, while the holes in the shells of the boiler and drum are 8 ins. diameter. The height from center line of boiler to top of smokestack is 31 ft. 3 ins. The auxiliary or donkey boiler is of the vertical type, and is rated at 10 HP. This is for the fire pumps, for washing decks, etc., when the main boiler is not in use. The fuel will consist of coal. The use of a surface condenser is made necessary by the fact that the dredge will work in salt water. The



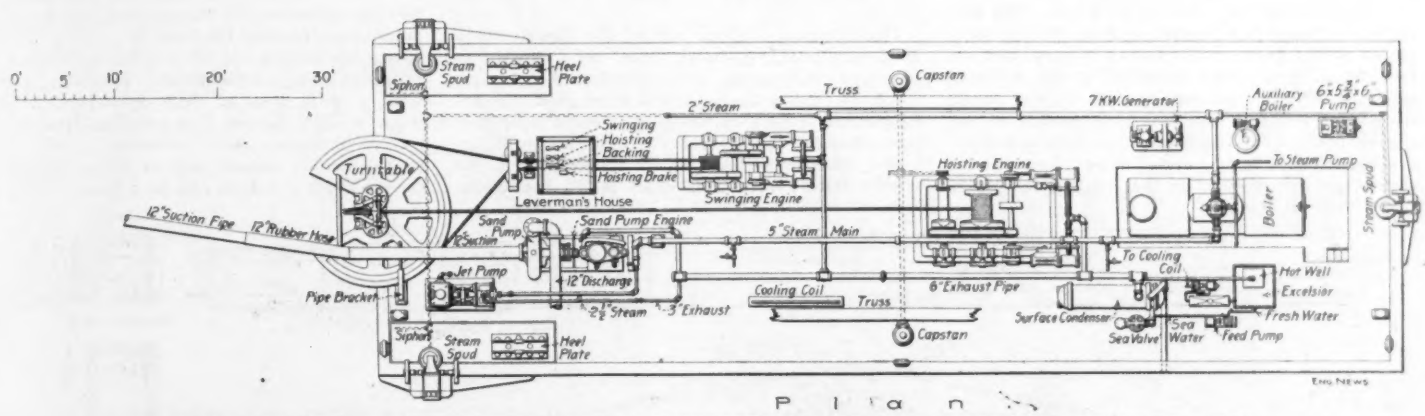


FIG. 2. MACHINERY PLAN AND ELEVATION OF COMBINATION HYDRAULIC AND DIPPER DREDGE FOR THE TAMPICO AND TUXPAN CANAL; MEXICAN GOVERNMENT.

Featherstone Foundry & Machine Co., Chicago, Builders. Charles E. Shillaber, Tampico, Contractor for Dredging.

steam main is 5 ins. and the exhaust main 6 ins. diameter. As meat and game can be procured in the wild country traversed by the canal, the dredge is fitted with a refrigerating and cold storage plant, as well as with an ice making plant. All this is in the forward end of the superstructure. A 5-HP. engine and a 5 × 5-in. ammonia compressor are used for the ice plant, which has a capacity of one ton per day. There are 150 incandescent electric lamps and a 13-in. searchlight, current for which is supplied from a 7-KW. 110-volt, direct-current generator, driven by a vertical engine with a single cylinder 5 × 4½ ins.

DIPPER DREDGE EQUIPMENT.

The material to be excavated by the dipper includes rock and clay, a 1½-yd. dipper being used for the former and a 2½-yd. dipper for the latter. The dipper handle is composed of two timbers 7 × 16 ins., 30 ft. long; they are 4½ ins. apart, with blocking pieces between. The lateral movement of the handle is effected by two cast-steel racks on the under side, gearing with two 8¾-in. pinions on a 4-in. shaft, pivoted in bearings on the boom. This is controlled by a pair of band brakes in 4t-ft. wheels, as shown in Fig. 3.

The steel boom, Fig. 4, is 45 ft. long, 5 ft. 3 ins. deep at the middle, and consists of two lattice girders, 28¼ ins. apart, with heavy batten plates at the middle and ends. The flanges are 6 × 6-in. angles, and the bottom flanges are reinforced by ⅝ × 8-in. cover plates and 4 × 3-in. angles, as shown. The top flanges are connected by lacing bars and batten plates, and the boom is further stiffened by a pair of 1½-in. truss rods, passing over saddles on the bearings for the dipper-handle shaft. The heel of this boom is pivoted to a 3-in. horizontal pin in bearings on the turntable, which is 14 ft. diameter. The head of the boom is guyed by a 1¾-in. wire cable from the head of the steel A-frame shown in Fig. 5. This has a spread of 27 ft., and the legs are 43 ft. long; each leg is composed of a pair of 12-in. channels, connected by lacing bars and batten plates. The feet of the A-frame are pivoted to 4-in. pins in heel plates on the deck, and the head is supported by two 1¾-in. wire cables anchored to the stern of the hull. The hoisting rope is a 1¼-in. wire cable, the end of which is attached to a shackle on the sheave frame over the bucket. It passes around a sheave in the boom, under the bucket sheave, around another sheave at the head of the boom and back through the boom to a grooved guide pulley at the heel, and thence along the deck to the hoisting engines. The swinging is effected by a 1¼-in. wire cable wound upon the drum of the swinging engines and passing around the grooved rim of the turntable, to which its ends are attached. A heel rope attached to the end of the dipper handle is connected with the mechanism of the brake on the dipper shaft, and a chain which is attached to the handle and led back through the hull to the backing drum of the hoisting engines is used for pulling the bucket down to the desired position for a fresh cut. There is also the usual tripping rope for releasing the latch which holds the bottom of the bucket in position.

The hoisting engines are of the Featherstone double-cylinder pattern, with cylinders 10 × 14 ins. fitted with balanced slide valves. The 4½-in. main shaft carries a 10-in. pinion which gears with a 60-in. spur wheel on the 5½-in. shaft of the hoisting drum, and this in turn gears with a 33½-in. spur wheel on the 4½-in. shaft of the backing drum. All gears are of cast steel, 2½ ins. pitch and 7 ins. wide on the face; and the shafts are of mild steel. The hoisting drum is 21 ins. diameter

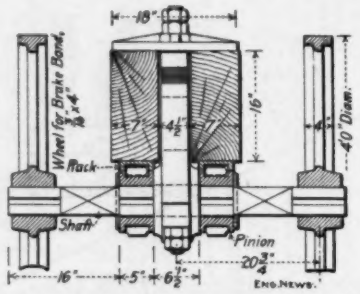


Fig. 3. Dipper Handle, With Shaft and Brake Wheels.

and 31¾ ins. long in the clear, while the backing drum is 10 ins. diameter. Each drum has a steel band brake, and is operated from its gear wheel by means of a friction band on a faced pulley outside the drum flange. The band is carried by the wheel and made to grip or release the drum by means of a horizontal steam cylinder, parallel with the shaft, which operates the grip levers of the band. Fig. 6 shows the friction belt and band brake of the hoisting drum. The main cylinders and shafts are all mounted in a continuous box frame.

The swinging engines are of the Featherstone double-cylinder reversible type, very similar to the hoisting engines, with cylinders 8 × 12 ins. They are equipped with a link valve gear, the arrangement being very similar to that of a locomotive. The 3 7-16-in. crank shaft carries an 8¾-in. pinion, gearing with a 39¼-in. spur wheel on the intermediate shaft. This shaft is 3¾ ins. diameter and has also a 10½-in. pinion gearing with the 48¼-in. spur wheel on the 4½-in. drum shaft. The first gears are 1½-in. pitch and 4-in. face, while the second gears are 2-in. pitch and 5-in. face. The drum is 18 ins. diameter and 12 ins. long, and is fitted with a driver which engages the main gear, four cushion springs being provided to take up shocks in reversing.

HYDRAULIC DREDGE EQUIPMENT.

For dredging sand and mud, there is a centrifugal pump with a runner 42 ins. diameter, and having 12-in. suction and 12-in. discharge openings. This is driven by a compound, vertical, inverted engine of the marine type, having cylinders 12 × 12 and 22 × 12 ins., and running at 12[illegible] revolutions per minute. This is placed [illegible] the bow, and its 12-in. suction pipe is connected by a 12-in. rubber hose to a suction pipe [illegible] long, the end of which is suspended by tackle [illegible] the head of the boom. The end of the pipe is fitted with a suction head, Fig. 7, having [illegible] about 26 ins. diameter, this head being [illegible] as to work practically on a horizontal [illegible]. To stir up and loosen the material there [illegible] nozzles ⅞-in. diameter through which [illegible] jets of water at about 300 lbs. pressure. [illegible] pump is placed near the sand pump, and [illegible] jet pipe is carried along the suction pipe to the head, which has a 4-in. annular chamber from which radiate the nozzles or jet holes.

The 12-in. discharge pipe is led from the pump to the side of the dredge, and the material may be delivered into barges or conveyed through pipes to be discharged into the swamps, rear of the channel. The builders have supplied 100 ft. of 12-in. pipe for this purpose, with wooden pontoons for supporting it in open water, while across marshes or soft ground it is carried on temporary supports of blocking or trestle bents.

SPUDS.

The boat is held in position by spuds, and is fed forward in its work by means of the dipper handle and by swinging lines led to shore anchorages or moorings. All the spuds are outside the hull, so that no spud wells are required. The spuds and spud grips are shown in Fig. 8. The two side spuds at the bow are oak timbers 18 × 20 ins., 20 ft. long; these slide between guide timbers 20 × 14 ins. The stern spud is the same length, 12 × 12 ins. in section. The inboard face of each spud has a rack, gearing with the pinion of a steam spud engine, as shown in the machinery plan, Fig. 2. The rack of the stern spud is longer than the others, so that the spud can be forced deep into the bottom of the channel and thus get a good purchase in holding the boat up to the work. The hoists can also be operated by hand. To hold the spuds at any desired height, each one is fitted with a grip, Fig. 8. This consists of a short piece of rack having a slot through the back to receive a 2½-in. shaft carried in a casting attached to the inboard face of the guide timbers. On the shaft is a 4-in. cam or eccentric which lies within the slot of the grip, and either forces the grip forward so that its teeth engage with those of the rack on the spud, or withdraws it so as to disengage the rack. The shaft is operated by two 30-in. handles fitted to the squared ends of the shaft.

All the machinery was erected complete at the Chicago shops, then marked, taken apart and boxed for shipment. The hull and superstructure were built at Tampico from timber sent from the United States, as already noted, and the machinery was then re-erected and put in place. This

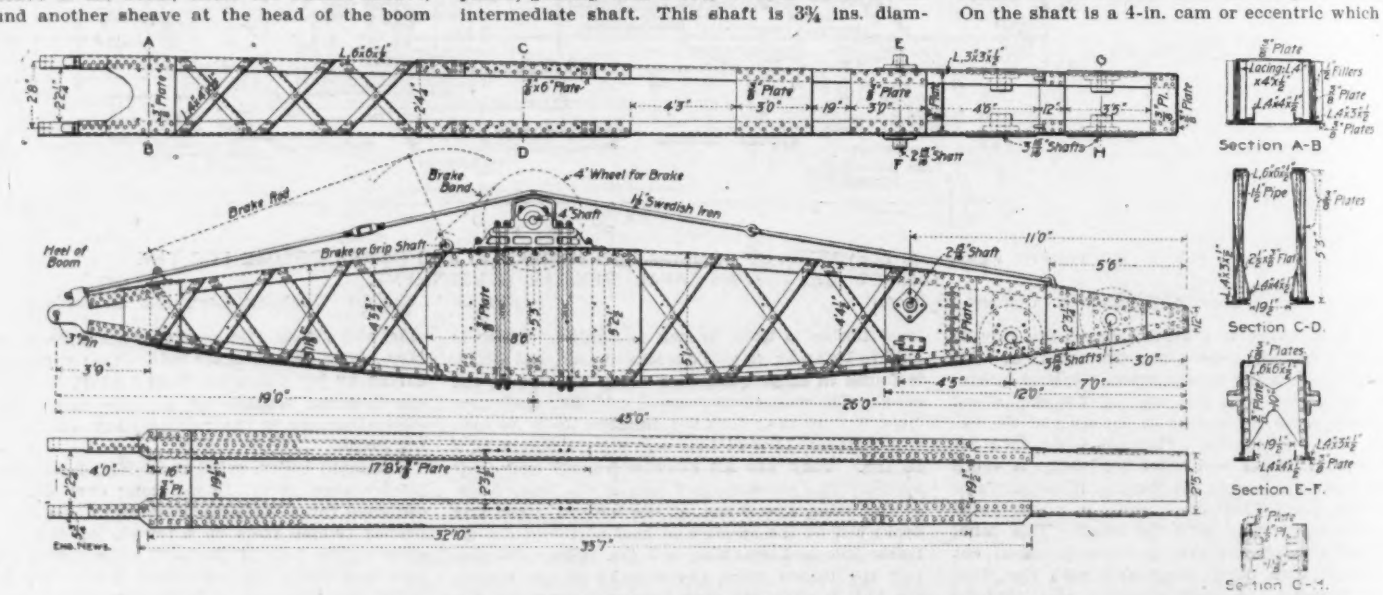


FIG. 4. 45-FT. STEEL BOOM FOR MEXICAN DREDGE.

work was done by the Mexican government employes under the direction of a foreman sent down by the Featherstone Foundry & Machine Co. The contract provided for the complete outfit of the vessel in condition for service, including tools and supplies, kitchen and table equipment, bedding, etc. All hardware is of brass, to provide against corrosion by the salt water. The dredge commenced actual work upon the canal on March 12, 1903.

THE FALLACY OF THE TESTS ORDINARILY APPLIED TO PORTLAND CEMENT.*

By Richard K. Meade.†

The qualities which are requisite for a good Portland cement are those which insure that concrete made from it shall be of sufficient strength to withstand any and all strains, stresses, and shocks to which it may be submitted, not only when first made and allowed to harden, but after the lapse of many years. The tests now applied to cement all aim to search out these qualities, or to show their absence, and may be classed under two general heads, (1) those designed to show the strength of concrete made from the cement, and (2) those designed to show its endurance. Under the first head come the tests for tensile strength, compressive strength, fineness to which the cement is ground, as this influences its sand carrying capacity and hence its strength, and time or rate of setting, as quick setting cement may not give sufficient time for proper manipulation of the concrete and slow setting cement may take too long to get its strength. Under tests for endurance, come the various so-called soundness tests, and possibly chemical analysis, as the quantities of magnesia and of sulphur trioxide present are supposed to have an influence upon its endurance.

It is the writer's intention in this paper to discuss some of the false conclusions that may be drawn from a too rigid interpretation of the results of these tests, even when the tests are properly manipulated. Improper manipulation or the varying results due to the personal equation of the operator or the different percentages of water used in gaging the mortar or the sundry modes of making, troweling, ramming, shaping, etc., briquettes and pats enter no part into it, and for the sake of simplicity it is supposed that the results of different operators agree.

It is well to say also at the outset that it is not the writer's intention to advocate any new system of cement testing nor to suggest that the present one be done away, but merely to point out certain weaknesses which limit its general application to every case, and to recommend a stronger leaning towards those tests which show the strength and endurance of sand mortar rather than neat cement.

*A paper read at the November meeting of the Lehigh Valley Section of the American Chemical Society.

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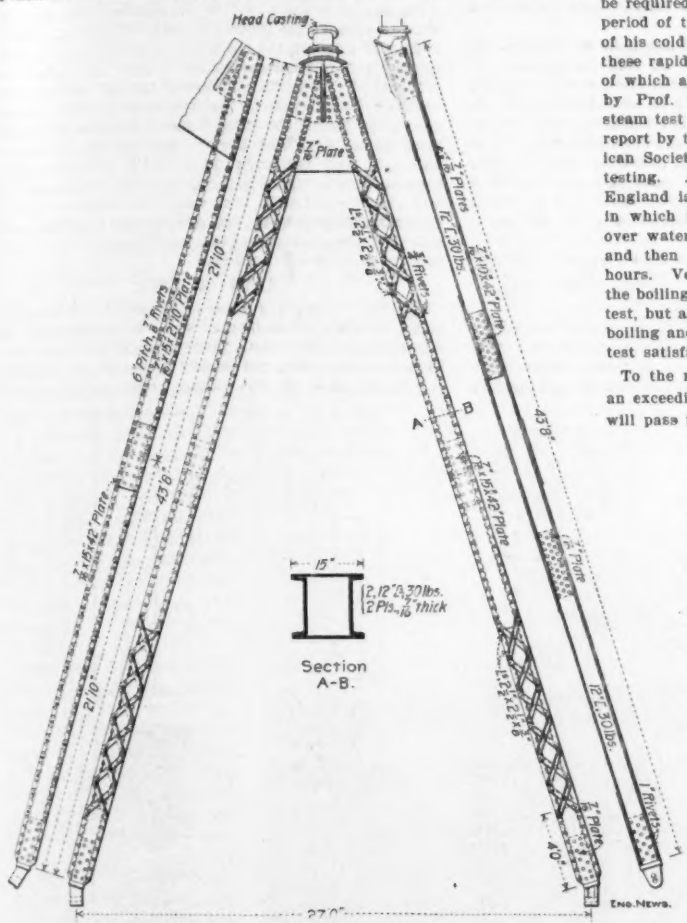

FIG. 5. STEEL A-FRAME FOR MEXICAN DREDGE.

Unquestionably much good concrete has been made from so-called unsound cement, and this is the key to the whole objection to the boiling test. It is probable that much of the first American Portland cement would not have passed the boiling test, yet it is upon the merits of the work done with this cement that engineers are now using American instead of imported cement. Butler gives a strong plea for the Faija test, and states that in the 20 years this test has been in use, no cases of failure in work by cement passing this test have come under his observation. If the Faija test is severe enough to exclude all bad cements, then the boiling test is needlessly severe, as it rejects many cements which pass Faija's test.

All cement probably contains some free lime. From the nature of the case this must be so since cement raw materials are not ground to a degree of fineness nor carried to a state of fusion which would permit of every molecule of lime coming in contact with a molecule of silica or alumina. Now there are limits beyond which if the uncombined or free lime goes certain results will take place. Let us suppose that with a very small percentage present the cement will fail on the boiling test but pass satisfactorily five hours in steam, and if a still larger percentage is present it will fail in the steam but pass the Faija test. Now, again, let us suppose that a neat mixture with a certain small percentage of free lime is sound, with a larger percentage a 3:1 sand mixture is sound, with a still larger percentage a 1:3:8 concrete is sound. (It is well understood that the tendency of cement to disintegrate is greater in a neat paste than in a sand mixture. And any one with experience in cement testing knows of cases where neat briquettes were disintegrated in time and yet the sand ones were sound and strong.) Now how do we know that the limit of lime which may be present in good cement (that is, cement which will make enduring concrete) is coincident with that maximum which may be present for a sound boiling test?

Nearly all advocates of the boiling test have tried to prove these two limits coincident by comparing the boiling test with the result of neat pats and neat briquettes. Usually the coincidence of a failure on the boiling test with either a warping or cracking of the neat pats or a loss of strength in the neat briquettes on long time tests is considered competent evidence in favor of the boiling test. In reality cement is seldom used neat. A cement which fails on the boiling test, whose neat briquettes fall off in strength after 7 or 28 days, yet whose sand briquettes increase in strength as they grow older, has certainly given evidence that it will make good concrete. In weighing evidence for the boiling test it must be remembered that we do not make this test to see if neat briquettes will fall in strength as they age or if neat pats will warp and decay, but whether sidewalks, piers, abutments, foundations, walls, floors and buildings of concrete not neat cement will be permanent, and the thing therefore to compare the boiling test with is concrete. Not until we can compare our laboratory records with many examples of both failures and successes in actual work will we have reliable data for forming our conclusions as to the reliability of the various tests for soundness.

At the last meeting of the American Society for Testing Materials, Mr. W. P. Taylor, of the Philadelphia Testing Laboratory, read a very carefully prepared paper upon the boiling test, in which he compared the results of neat briquettes and neat pats with the results of the boiling test. As is usual, he considered a falling off of the strength of neat briquettes on long time tests and a cracking and warping of the neat cold water pat as being positive evidence of the presence of injurious constituents in the cement. He gives these figures:

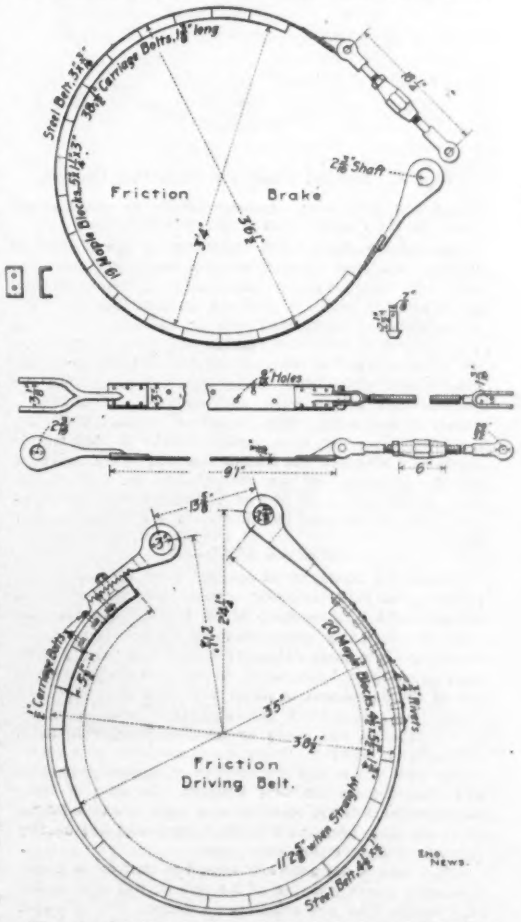

Fig. 6. Friction Belt and Band Brake of Hoisting Engine for Dipper Dredge.

Of all the samples failing to pass the boiling test 34% of them developed checking or curvature in the normal pats or a loss of strength in less than 28 days. Of those samples that failed in the boiling test but remained sound for 28 days, 3% of the normal pats showed checking or abnormal curvature in two months, 7% in three months, 10% in four months, 26% in six months, and 48% in one year; and of these samples 37% showed a falling off in tensile strength in two months, 39% in three months, 32% in four months, 63% in six months, and 71% in one year. Or taking all these together, of all the samples that failed in the boiling test 80% of them gave evidence in less than a year's time of possessing some injurious quality.

On the other hand, of those cements passing the boiling test but one-half of 1% gave signs of failure in the nor-

mal pat tests, and but 1% showed a falling off in strength in a year's time.

Mr. Taylor, after making these comparisons, acknowledges their fallacy by one of the closing paragraphs of his paper:

Now finally we come to what is after all the most vital question of all, and this is the relation of the results of the boiling test to the conditions found in actual work, and there every tester of cement runs up against a stumbling block, for which almost every one connected with testing can cite instances of failures in the boiling being corroborated by failure in the work, it nevertheless cannot be denied that in the vast majority of cases work done with cement determined in the laboratory to be unsound will give most excellent results in practice and show not the remotest sign of any sort of failure.

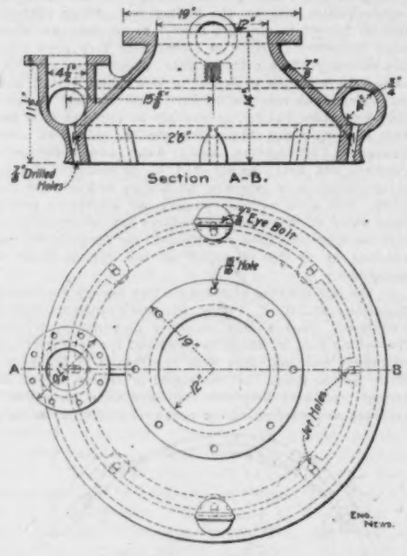

Fig. 7. Suction Head for Hydraulic Dredge.

Experiments made by a committee of the Society of German Portland Cement Manufacturers in connection with the Royal Testing Laboratory at Charlottenburg forced them to report in 1900 and again in 1903 that none of the so-called accelerated tests for constancy of volume was adapted to furnish a reliable and quick judgment in all cases concerning the applicability of a cement. The experiments which they made consisted in putting the cement into actual work and observing it during a period of four years. The committee recommend the 28-day cold water pat as a standard test. If this test is taken as a standard the boiling test will reject two good cements for every bad one, according to Mr. Taylor's figures, as he states only 34% of the failures on the boiling test were corroborated by failures in the 28-day normal pats.

TENSILE STRENGTH.

Perhaps the results of no test are given so prominent a place in the manufacturers' advertisements as the neat strength of briquettes made of his brand. We hear the question constantly propounded by the prospective purchaser of "how much does your cement pull" and a thousand pound neat 7-day break is considered compensation for all the deleterious qualities a cement may have. In reality, the neat break is not of so much value as we are apt to suppose, and taken by itself is little criterion of the quality of cement. Unsound cements often give notoriously high results and the addition of plaster or gypsum will also increase the neat strength. In both of these instances there is apt to be on long time breaks a falling off in strength, permanent in the former case and usually only temporary in the latter case.

A fact that is not generally known is that up to a certain point coarse grinding of the cement will give higher neat results than fine grinding. A cement 75% of which passed a 200-mesh sieve gave after seven days a neat strength of 912 lbs. and a sand strength of 256 lbs. The finer portion of this cement, that passing a 200-mesh sieve, gave for the same period a neat strength of 715 lbs. and a sand strength of 463 lbs. A sample of float (i. e., the fine cement dust which collects on the beams, etc., in a cement mill and which is nearly all of it an impalpable powder) gave for seven days a neat strength of 679 lbs., and a sand strength of 558 lbs. This dust mixed with 25% of coarse cement, i. e., that passing a 100-mesh screen but retained on a 200-mesh, gave 919 lbs. neat, but only 252 lbs. sand strength on seven days. Certainly in both these cases neat strength would have given us a poor comparison of the value of the two products. As cement is always used with sand, the sand strength is the important thing.

Another point which has often been brought against cement, and American cements in particular, is that of a permanent drop in tensile strength after the 28-day test. In fairly quick setting cements with their usual low lime content and to which the normal amount of gypsum or plaster has been added, this drop is rarely met with and is probably then due to improper manipulation of the test. In cements high in lime, without being necessarily unsound, or in cements to which a large addition of plaster or gypsum has been made, this drop is often met with. In unsound cements it is usually met with, often after the seven-day test.

While it is true that any drop in strength indicates a disrupting action, still cement is never used neat, and in the vast majority of cases when a cement shows a slight falling off in neat strength, the sand strength increases with age. Humphreys states that the compressive strength of neat cement does not experience this drop when the cement is sound, even if the tensile strength does fall off somewhat after the 28-day test. An important fact, if true, as cement is seldom if ever used in tension. This brings us to the question if it is not a fallacy to subject a material to a tensile stress to see if it will stand a compressive one.

Coarse grinding of the cement has some influence on the increase in strength with age. A very fine cement increases neat very little after seven days, while a coarser one keeps on increasing. This is no doubt due to the fact that the coarse particles are acted on much slower than the fine ones, and solution and crystallization of these go on after the finer ones are all hydrated. The following experiment was made with the same cement. Cement A is just as it comes from the mills. Cement B is cement A with the coarse particles (residue on a No. 200 sieve) removed:

Age.....	7 days	28 days.	3 mos.	6 mos.	9 mos.
Cement A.....	618	695	675	725	750 lbs.
Cement B.....	518	546	535	510	549 "

FINENESS.

The most rigid fineness specification could be filled by a cement which would be many degrees too coarse. Some of the older specifications could be easily filled by a product which would show almost no setting qualities and no sand carrying capacity.

If a sample of clinker is crushed in an iron mortar by a pestle and sieved as fast as it is ground through a 100-mesh screen a product will be obtained 100% of which will pass a 100-mesh screen. Many of the older specifications call for only 90%. If a pat is made of this cement it will just about cohere. If, however, the fine particles are sieved through a 200-mesh screen and the flour washed off the coarse particles by benzine and the latter driven off by heat, the product will still all pass a 100-mesh sieve and yet will have no setting properties. If another sample is ground in a mortar and sieved after every few strokes of the pestle through a 200-mesh screen, the resulting product will all pass a 200-mesh screen and yet it will be almost worthless as a cement. When washed free from its flour with benzine it will just about hold together. In the writer's laboratory there is a Braun's Gyratory Muller for grinding samples, in which the grinding is done by an enclosed round pestle revolving in a semi-hemispherical mortar. In the bottom of the mortar is a hole which can be stopped by a plug. The grinding may be done in two ways, one by feeding the sample into the hopper in the cover and allowing it to work its way out at the bottom, then sieving out the fine material from the coarse, and returning the latter through the grinder and so on until all has passed the sieve. The other, by placing the plug in the bottom of the mortar and allowing the pestle to work upon the material until the latter has reached the desired fineness. Two samples of cement were prepared from the same lot of clinker by these two methods. One sample, the one made by passing the clinker through the muller and sieving out the 200-mesh particles after each grind, would of course all pass a 200-mesh sieve. The other sample, the one made by grinding the whole sample to the desired fineness without screening, tested 90% through a 100-mesh sieve and 76.5% through a 200-mesh sieve. Sand briquettes were made of these two lots of cement with the following results:

	7 days.	28 days.	3 mos.	6 mos.
Samples made by grinding and screening to fineness (all 200-mesh.....	Broke in clips	Broke in clips	Broke in clips	28 lbs.
Grinding to fineness without screening	215	295	325	315 lbs.

The cementing value of Portland cement depends upon the percentage of those infinitesimal particles which we call flour. No sieve is fine enough to tell the quantity of these present. At the same mill it is probable that the sieve test is relative, but to the engineer who is called upon to examine the product of many mills using different system of grinding the sieve test is hardly to be expected to give the relative percentage of flour in each. The products of the Griffin mill and of the ball and tube mill probably differ much in the percentage of flour present, even when testing the same degree of fineness on the 200-mesh sieve. Even with the ball and tube mill system one ball mill and two tube mills would probably give a product with a higher percentage of flour than one tube mill and two ball mills, even when the cement was ground to the same sieve test. The size screen on the ball mills probably also influences the percentage of flour in a product of a certain fineness.

RATE OF SET.

The test for setting time is of course influenced by many laboratory conditions, such as temperature and manipulation. This test, however, is seldom used as a basis of comparison, but merely to see if the cement is sufficiently slow in its setting action to be properly manipulated or whether it hardens rapidly enough to satisfy the requirements of the work on which it is to be used. The fallacy in the case of this test lies in the terms initial and final set. These terms are meaningless, as set is a chemical reaction which begins with the addition of the water and goes on indefinitely, or merges into possibly another chemical reaction if you wish to consider set and hardening as different phenomena. To fix two points in this reaction by means of loaded wires and call them the beginning and the end of the reaction is a misnomer. It would be better to use the terms heavy and light Gilmore wire or some similar term if other apparatus for determining the set is used.

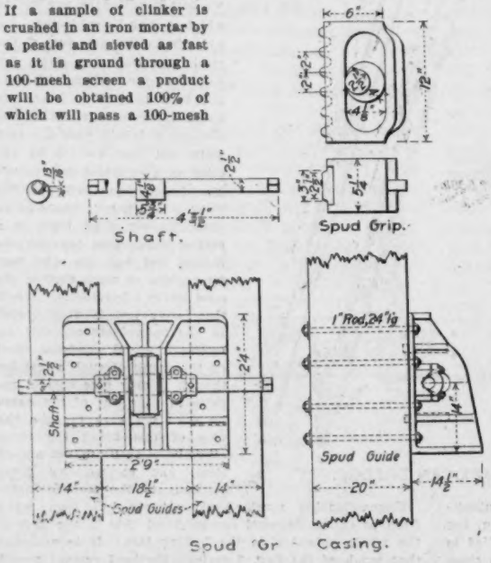
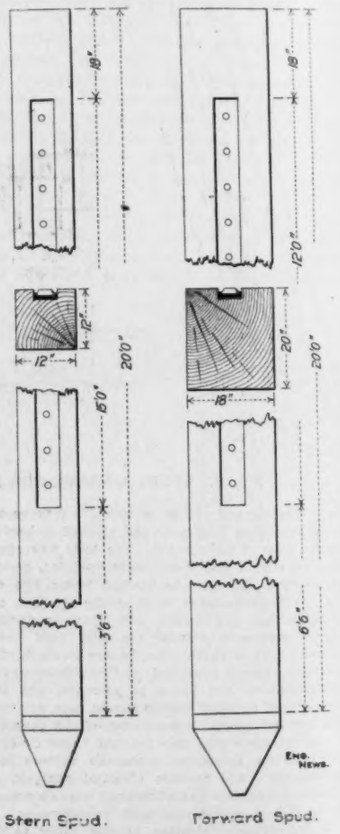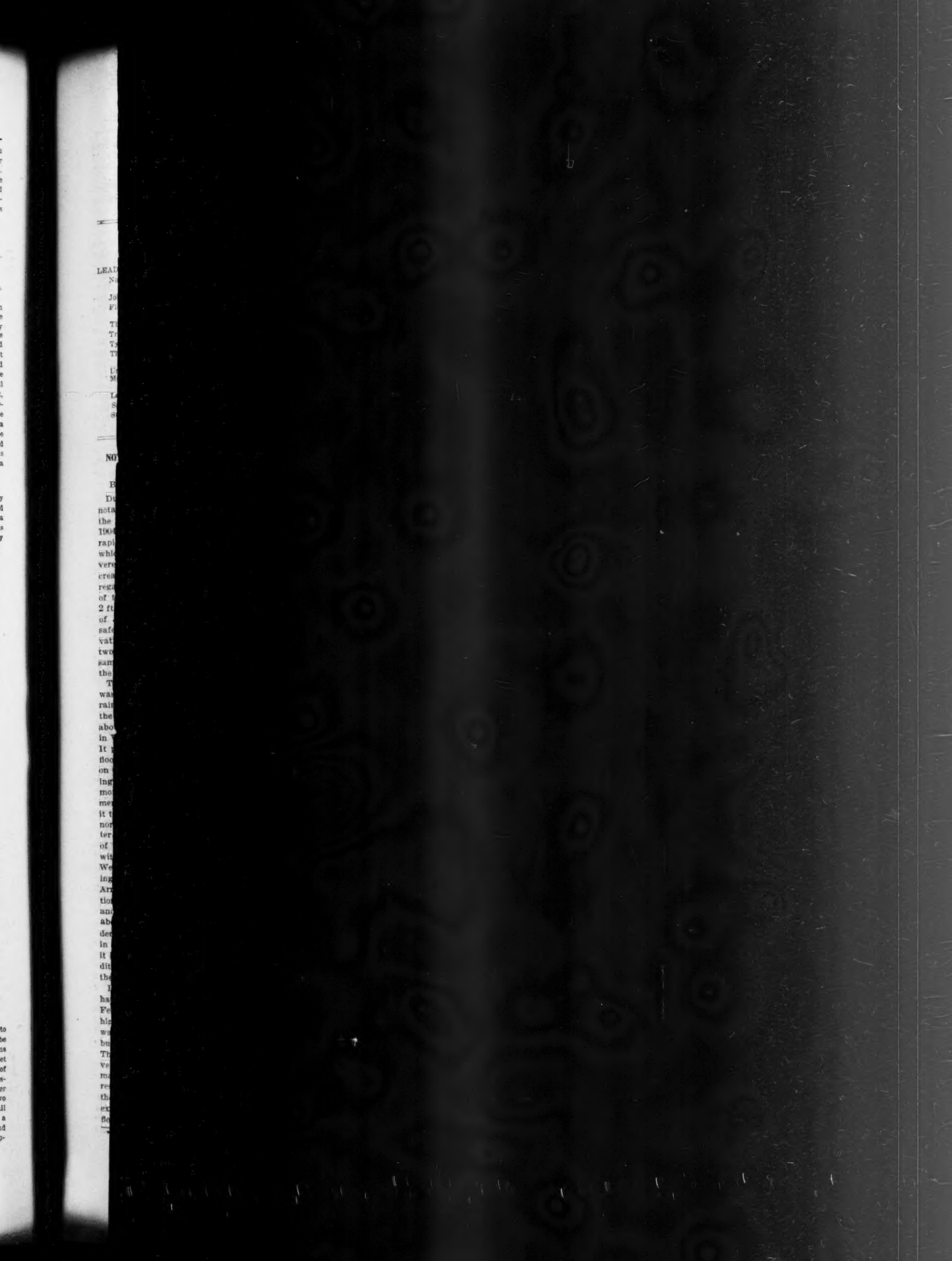
FIG 8. SPUDS AND SPUD GR.PS.